NATIONAL SCIENCE FOUNDATION

FY 2024 Budget Request to Congress

March 13, 2023

NOTES

Table and Figure Notes

Numbers in the tables and figures may not sum to totals due to rounding.

Common Acronyms Used in NSF's Budget Submission

Appropriation Accounts

- AOAM - Agency Operations and Award Management
- EDU - STEM Education
- MREFC - Major Research Equipment and Facilities Construction
- NSB – National Science Board
- OIG - Office of Inspector General
- R&RA - Research and Related Activities

Directorates and offices

- BFA - Office of Budget, Finance, and Award Management
- BIO - Directorate for Biological Sciences
- CISE - Directorate for Computer and Information Science and Engineering
- ENG - Directorate for Engineering
- EDU - Directorate for STEM Education
- GEO - Directorate for Geosciences
- GEO: OPP - Office of Polar Programs (a Sub-Activity within the Directorate for Geosciences)
- MPS - Directorate for Mathematical and Physical Sciences
- SBE - Directorate for Social, Behavioral, and Economic Sciences
- TIP - Directorate for Technology, Innovation, and Partnerships
- OIRM - Office of Information and Resource Management
- OISE - Office of International Science and Engineering
- OIA - Office of Integrative Activities [organizational unit]
- IA - Integrative Activities [budget activity]

National Science and Technology Council Crosscuts:

- CET - Clean Energy Technology
- NITRD - Networking and Information Technology Research and Development
- NNI - National Nanotechnology Initiative
- USGCRP - U.S. Global Change Research Program
- QIS - Quantum Information Science

NSF-Wide Investments

- GRFP - Graduate Research Fellowship Program
- INFEWS - Innovations at the Nexus of Food, Energy, and Water Systems
- IUSE - Improving Undergraduate STEM Education
- I-Corps™ - NSF Innovation Corps
- NRT - NSF Research Traineeship
- SaTC - Secure and Trustworthy Cyberspace

Notes

NSF Big Ideas

Research Big Ideas

- HDR - Harnessing the Data Revolution for 21st-Century Science and Engineering
- FW-HTF - The Future of Work at the Human-Technology Frontier
- NNA - Navigating the New Arctic
- URoL - Understanding the Rules of Life: Predicting Phenotype
- WoU - Windows on the Universe: The Era of Multi-messenger Astrophysics

Enabling Big Ideas

- GCR - Growing Convergence Research at NSF
- Mid-scale RI - Mid-scale Research Infrastructure
- NSF's Eddie' Berniece Johnson INCLUDES Initiative - Inclusion Across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science

Other Frequently Used Acronyms

- STEM - science, technology, engineering, and mathematics
- R&D - research and development
- O&M - operations and maintenance
- AI - artificial intelligence
- MSI – minority-serving institutions

NSF FY 2024 BUDGET REQUEST TO CONGRESS
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NSF FY 2024 Budget Request to Congress

The National Science Foundation Act of 1950 (Public Law 81-507) sets forth our mission: ***"To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..."***

The National Science Foundation's FY 2024 Budget Request of $11.314 billion will fund research and education across all fields of science, technology, engineering, and mathematics (STEM), supporting the economic and national security interests of the Nation and its workforce. Simply put, NSF investments are critical for modernizing the existing research and development infrastructure, expanding the STEM workforce, and promoting equitable access to scientific learning and resources to unleash the full potential of the Nation's R&D enterprise.

Over the past seven decades, NSF has funded research and researchers, innovations and innovators, and infrastructure, resulting in transformational technologies and incredible benefits to the Nation. Many of the technologies and industries that are at the root of US economic competitiveness and sustainability — advanced manufacturing, advanced wireless, artificial intelligence, biotechnology, microelectronics and semiconductors, quantum information science and engineering — are grounded in sustained NSF support. The Internet, Qualcomm, 3D printing, economic theory underpinning spectrum auctioning and kidney exchanges, and even the polymerase chain reaction (PCR) testing technique that was critical in the fight against COVID-19 were all supported by early NSF investments.

In FY 2024, the Foundation will continue to move the needle forward on scientific priorities articulated in the CHIPS and Science Act. The agency will strengthen at speed and scale its capacity to produce breakthroughs, to innovate and identify new industries, to accelerate the translation of research results to practice and commercialization, and to cultivate the diverse workforce needed to power our country forward. NSF has the know-how and energy to help create this brighter future.

The NSF Director's vision for this future is expressed in **three pillars** that point to opportunities to continue building on recent investments, particularly those enabled by the CHIPS and Science Act and by the FY 2023 Omnibus and the Disaster Relief Supplemental appropriations. These are:

1. **Strengthening Established NSF**
   For more than 70 years, NSF has been making investments that expand the frontiers of knowledge and technology. This will continue to be our central focus: to accelerate discovery and enhance state-of-the-art research capabilities.

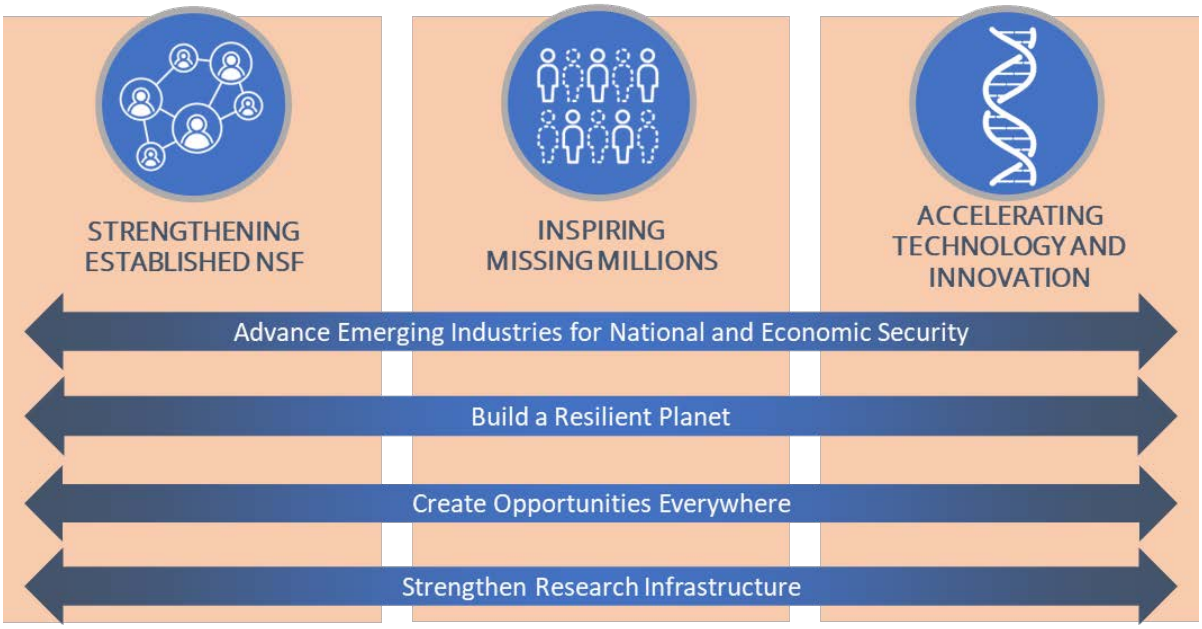
2. **Inspiring Missing Millions**
   The National Science Board (NSB) in its *Vision 2030*[1] report states, "Faster progress in increasing diversity is needed to reduce a significant talent gap" and they name that talent gap the "Missing Millions." NSB estimates that, for the S&E workforce to be representative of the U.S. population in FY 2030, the number of women in STEM must nearly double from the number in the 2020 U.S. S&E workforce, the number of Black or African Americans must more than double, and the number of Hispanic or Latinos must triple. These estimates are based on projections from the U.S. Census and Bureau of Labor Statistics, together with data from the National Center for Science and Engineering Statistics (NCSES), which is housed at NSF.

   Every demographic and socioeconomic group in every geographic region of the country has talented people who can participate in STEM and contribute to the innovation enterprise. In our effort to bring the "Missing Millions" into the STEM workforce, we will continue scaling up existing pathways into STEM fields and creating new tracks. NSF's commitment to finding talent provides opportunities that lead to a well-paid workforce and a vibrant U.S. economy.

3. **Accelerating Technology and Innovation**
   Global competition for leadership and talent in science, engineering and technology is at an all-time high, inspiring and motivating us to accelerate our progress. For the U.S. to remain in the vanguard of competitiveness for decades to come, we must continue to invest in advancing breakthrough technologies, translating research results to the market and society, and nurturing diverse talent by creating opportunities for everyone everywhere. To enable these investments, NSF will accelerate partnerships with other agencies, private industry, philanthropy, and like-minded countries to foster environments that leverage resources and deliver results.
   .

In NSF's FY 2024 Budget Request, these three pillars infuse four major themes— **Advance Emerging Industries for National and Economic Security, Build a Resilient Planet, Create Opportunities Everywhere, Strengthen Research Infrastructure**. These themes align with the Administration's priorities of expanding basic research to tackle hard topics and empower new approaches to applied research that spur technology transfer. The themes, expanded upon below, appear repeatedly in the broad portfolio of fundamental research that is the heart of NSF's mission. They bring to life new efforts and connect existing efforts throughout the research portfolio. They also point to opportunities envisioned in the CHIPS and Science Act.

[1] www.nsf.gov/nsb/publications/2020/nsb202015.pdf



NSF's four themes that shape our FY 2024 Request are:

Advance Emerging Industries for National and Economic Security Theme

As the U.S. faces intensifying global competition for science and technology leadership, NSF will strengthen and scale investments in breakthrough technologies, innovation, and translation by expanding support for basic research, nurturing technology transfer, and empowering new approaches to potential application of research breakthroughs. NSF's investment in Emerging Industries for National and Economic Security will also focus on nurturing diverse talent. Building on NSF's deep relationships with over 2,000 of America's leading research institutions, we plan to harness the innovative spirit that exists in all corners of the country.

The FY 2024 Request advances research by creating conditions to expand research from the lab to the market and society and by targeting investments in new industries and people. For example:

- **The Directorate for Technology, Innovation, and Partnerships (TIP)** ($1,185.63 million), in close collaboration with all of NSF's directorates and offices, advances key technology focus areas to address societal and economic challenges and opportunities; accelerates the translation of research results from the lab to the market and society; and cultivates new education pathways leading to a diverse and skilled future technical workforce comprising researchers, practitioners, technicians, entrepreneurs, and educators. Building on NSF's longstanding leadership in science and engineering research and education, TIP serves as a crosscutting platform that leverages, energizes, and rapidly advances use-inspired research and innovation. Further, TIP opens new possibilities for research, innovation, and education by catalyzing strategic partnerships linking academia; industry, including startups and small businesses; federal, state, local, and tribal governments; nonprofits and philanthropic organizations; civil society; and communities of practice to cultivate 21st-century innovation ecosystems that give rise to future, high-wage, good-quality jobs and enhance the Nation's long-term competitiveness.

  Specific programs include:

- **NSF Regional Innovation Engines (NSF Engines)** ($300.0 million), authorized in the CHIPS and Science Act, will catalyze new business and economic growth in those regions of America that have not fully participated in the technology boom of the past several decades. They will advance equitable and inclusive use-inspired research, entrepreneurship, and workforce development to nurture and accelerate regional industries. Collectively, they will contribute to long-term U.S. competitiveness.

- **Experiential Learning in Emerging Industries (ExLENT)** ($50.0 million) will support inclusive experiential learning opportunities designed to provide cohorts of diverse learners with the crucial skills needed to succeed in the key technology focus areas and prepare them to enter the workforce ready to solve the Nation's most pressing societal, economic, national, and geostrategic challenges. Of note, ExLENT will enable those active in the workforce today to pivot into key technology focus areas to pursue high-wage, good-quality jobs.

- **NSF Entrepreneurial Fellows** ($10.0 million), authorized in the CHIPS and Science Act, will provide a diverse cohort of Ph.D.-trained scientists and engineers with resources, including lab space, to mature promising ideas and technologies from the lab to the market and society. These fellows will forge connections between academic research and government, industry, and finance, becoming leaders in technology translation.

- **Accelerating Research Translation (ART)** ($45.0 million), in alignment with CHIPS and Science Act authorization, will support institutions of higher education that wish to build the necessary infrastructure to boost their overall institutional capacity to accelerate the pace and scale of translational research. Importantly, ART will result in a network of ambassadors who will champion translational research throughout the Nation.

- **NSF Convergence Accelerator** ($100.0 million) will regionalize its approach to accelerate the translation of use-inspired research by investing in regional cohorts of transdisciplinary, multi-sector teams pursuing technology solutions to location-specific challenges in food and agriculture, disaster response and mitigation, and transportation, to name a few.

FY 2024 funding will also catalyze research and innovation in these key areas to drive investments in Emerging Industries that address the following:

- **Advanced Manufacturing** ($453.86 million) investments will accelerate breakthroughs in manufacturing materials, technologies, and systems through fundamental, multidisciplinary research that transforms manufacturing capabilities, methods, and practices. NSF investments will further advanced manufacturing through advanced energy and industrial efficiency technologies, resilient manufacturing strategies, novel methods in engineering biology, next-generation materials, sustainable processes to support a circular economy, and the power of data science, automation, robotics and machine learning to intelligently design and develop future approaches that are secure, sustainable, and resilient to natural and anthropogenic disasters.

- **Advanced Wireless** ($179.17 million) investments will advance knowledge gaps and innovations in areas critical to future generations of communications technologies and networks, such as

wireless devices, circuits, protocols, and systems; mobile edge computing; distributed machine learning and inference on mobile devices; human-machine-network interactions; and dynamic spectrum allocation and sharing, while ensuring innovation and security for all users. For example, this investment will serve to advance both new active spectrum applications and spectrum used for non-commercial purposes, such as advanced receiver design and interference mitigation techniques for radio astronomy and atmospheric science. NSF investments will provide the backbone that connects users, devices, applications, and services that will continue to enrich America's national and economic security.

- **Artificial Intelligence** ($796.48 million) (including machine learning, autonomy, and related advances) investments will bring together numerous fields of scientific inquiry—including computer and information science; cognitive science and psychology; economics and game theory; education research; engineering and control theory; ethics; linguistics; mathematics; and philosophy—to advance the frontiers of trustworthy AI, including advancing perception, learning, reasoning, recommendation, and action in the context of specific fields and economic sectors. NSF investments will support the development of new foundational AI theory and implementation techniques, as well as novel AI methods that are inspired by use cases in specific application domains and contexts.

- **Biotechnology** ($470.05 million) investments will support fundamental research, infrastructure, and education to understand and harness biological processes for societal benefit. It will propel advances in genomics, bioinformatics and data analytics, structural and computational biology, biophysics, synthetic and engineering biology, tissue and metabolic engineering, medical technology, development of new types of biomaterials, bio-inspired data storage and microelectronics, and biomanufacturing, as well as accelerate the ability to harness biological systems to create goods and services that contribute to agriculture, health, security, manufacturing, and resilience to climate change, including natural and anthropogenic disaster prevention and mitigation. As part of the National Engineering Biology Research and Development Initiative codified in the CHIPS and Science Act, NSF will make investments that advance areas of research at the intersection of engineering and the biological, physical, chemical, data, computational and information sciences and engineering, and social, behavioral and economic sciences to accelerate scientific understanding and technological innovation in engineering biology as well as assure public acceptance of the products of engineering biology.

- **Microelectronics and Semiconductors** ($209.68 million) investments will address the microelectronics and semiconductor challenges facing our Nation due to technological and global trends, such as the end of Moore's Law and offshoring of semiconductor fabrication and manufacturing, by supporting work in semiconductor discovery, development, and fabrication, leading to future domestic and related electronics foundries, as well as the design ecosystem of secure, sustainable microelectronic systems and devices based on them. This investment will enable future advanced computing systems, including quantum computing and networking technologies. Investments will also advance next-generation materials and highly parallel chip designs that will improve the performance of AI algorithms as well as integrate advanced energy efficiencies for low-power and high-performance devices that will drive a mobile and wireless future, and smart sensors that will interface between biosystems and electronics. Additionally, the CHIPS and Science Act provides NSF with $200 million in appropriated funding over five years for microelectronics workforce development activities.

- **Quantum Information Science (QIS)** ($332.67 million) investments will pioneer development of quantum computing, communication, sensing, and networking to advance information processing, transmission, and measurement in ways that classical approaches can only do much less efficiently, or not at all. This investment will develop proof-of-concept devices, tools, systems, and applications with a demonstrable quantum advantage over their classical counterparts. For example, quantum sensors will enhance resolution and detection capabilities.

Build a Resilient Planet Theme

Resilience is the watchword as the U.S. and the world begin to feel the impacts of a changing climate and the growing need for clean, reliable, sustainable energy. Without resilience we are at the mercy of heat waves, droughts, floods, wildfires, rising oceans, and other extreme events, as well as power disruptions, economic instability, food insecurity, and deleterious effects on human health. NSF's Build a Resilient Planet initiative takes on these multifaceted challenges. The magnitude of these challenges demands an accelerated and integrated NSF-wide approach to engage scientists and engineers across disciplines through convergent research that addresses societal needs and integrates research and education.

NSF will take action to advance knowledge, empower communities, and generate innovative technological solutions. FY 2024 NSF investments will advance the priorities of the CHIPS and Science Act. Funding will focus on action to meet the urgent demands of the climate crisis on people, places, and economies. Investments will include:

- **Clean Energy Technology (CET)** ($550.51 million) and NSF's clean-energy investments in high-risk, high-reward ideas from researchers across the science and engineering spectrum create broad new understanding and innovations that may increase energy efficiency, enhance sustainability, mitigate climate change, or lead to other societal benefits. NSF's investments in integrated clean energy research and education span longstanding programs as well as focused new solicitations and will continue to advance the fundamental science and engineering underlying clean energy technologies and infrastructure to continue to decrease energy prices and build our domestic supply chain. NSF also will support multidisciplinary research in areas such as affordable green housing and sustainable systems for clean water, clean transit, and other infrastructure.

- **U.S. Global Change Research Program (USGCRP)** ($1,035.06 million) supports research that contributes to the USGCRP goals to (1) advance scientific knowledge of the integrated natural and human components of the Earth system and (2) inform decisions by providing the scientific basis to inform and enable timely decisions on adaptation and mitigation. In FY 2024, NSF will continue to engage with other USGCRP agencies on priorities from intra-seasonal to centennial predictability, predictions, and projections; water cycle research; impacts of climate change on the nation's critical ecosystems, including coastal, freshwater, agricultural and forests systems; understanding the impacts of global change on the Arctic region and effects on global climate; and fundamental research on actionable science. In addition, NSF will seek greater integration of social-science research, methodologies, and insights into understanding and supporting responses to global change, improving computing capacity, and maintaining needed observational capabilities over time.

- **Climate Equity Fellowships** ($15.0 million) will allow students and researchers to develop a deeper understanding of the disparate impacts of climate change on disadvantaged or underserved communities and equip them to work to mitigate those impacts. The program will train students in climate science, disparities in climate impacts on different communities, engagement with such communities, and climate-related policies, to enable them to lead and advance climate equity.

NSF will continue to enhance its investment in **greenhouse gas (GHG) research**, where NSF-funded projects will develop measuring and monitoring strategies as well as reporting and verification systems with an emphasis on methane.

Programmatic examples supported in FY 2024 include further development of the **National Discovery Cloud (NDC) for Climate** ($30.0 million), a resource that will federate advanced compute, data, software and networking resources, democratizing access to a cyberinfrastructure ecosystem that is increasingly necessary to further climate-related S&E as well as investment in the **OISE Global Centers (GC)** program ($25.0 million), an international larger-scale collaborative activity to enable interdisciplinary and international teams to address grand societal challenges through use-inspired research with topics related to climate change and clean energy.

Create Opportunities Everywhere Theme

NSF is strongly committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans, wherever they are found. Create Opportunities Everywhere (COE) is a comprehensive approach for attracting, supporting, and advancing groups underrepresented in STEM. This whole-of-NSF strategy incorporates all directorates and offices and surpasses prior efforts by striving to ensure equity in program delivery, while building on the concept of the "Missing Millions." It focuses on expanding access and inclusion in STEM along individual, institutional, and geographic lines.

In FY 2024, NSF intends to apply four guiding principles to create and implement opportunities everywhere: (1) address research equity, (2) build capacity, (3) foster collaborations and partnerships, and (4) support the next generation of researchers. For individuals, NSF will focus on groups that are underserved and underrepresented in STEM, and continue efforts to support individuals who are extremely underrepresented in STEM (those with low presence and/or low visibility in NSF programs) including those at the intersections of various dimensions of identity. For institutions, NSF will be more intentional in engaging Minority Serving Institutions (MSIs) and Emerging Research Institutions (ERIs) in our programming, focusing on the importance of bridge programs (funding open to all institutions that encourage participation by MSIs and ERIs). For jurisdictions, U.S. states and territories, NSF will expand support for individuals and institutions in EPSCoR jurisdictions to ensure geographic diversity.

The CHIPS and Science Act provides authorization for NSF support for diversity at the individual, institutional, and jurisdictional levels. At the individual level, CHIPS and Science authorizes programs that empower individuals through scholarships, fellows, traineeships, and project activities that enrich STEM education at all levels. At the institutional level, awards to minority serving colleges and universities, including community colleges, will lead to greater opportunities for all students and faculty. Finally, at the jurisdictional level, NSF is working toward more geographical diversity across the portfolio, especially to rural and urban institutions that serve diverse students.

NSF's commitment to finding talent provides opportunities that build strong STEM pathways that lead to a well-paid workforce and support the U.S. economy. To that end, the following programs are increased in the FY 2024 Budget Request over the FY 2023 Estimate Base.

- **Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED)** ($50.0 million) will improve the Nation's research support and service capacity at emerging and underserved research institutions. GRANTED will use a variety of mechanisms and programs to further NSF's reach in advancing the geography of innovation and engaging the Missing Millions. GRANTED activities will support the enhancement of research administration and post-award management as well as the sharing and implementation of effective practices that lead to competitive proposal development for external funding in STEM research and training. GRANTED funding in FY 2024 will aim to mitigate the barriers to competitiveness at underserved institutions, including minority-serving institutions and emerging research institutions within the Nation's research enterprise.

- **Alliances for Graduate Education and the Professoriate (AGEP)** ($15.50 million) program aims to increase the number of African American, Hispanic American, Native American Indian, Alaska Native, Native Hawaiian and Native Pacific Islander (or AGEP population) faculty in STEM at all types of institutions of higher education. The program funds projects that increase the understanding of institutional policies and practices to help doctoral candidates, postdoctoral scholars, and faculty improve their academic pathways to tenure and promotion in the STEM professoriate.

- **Centers of Research Excellence in Science and Technology (CREST)** ($41.0 million) enhance the research capabilities of minority-serving institutions (MSI) through the establishment of centers that effectively integrate education and research. CREST promotes the development of new knowledge, enhancements of the research productivity of individual faculty, and an expanded presence of students historically underrepresented in STEM disciplines.

- **Eddie Bernice Johnson INCLUDES Initiative (NSF INCLUDES)** ($50.50 million) is a comprehensive national initiative to enhance U.S. leadership in STEM discoveries and innovations focused on NSF's commitment to diversity, inclusion, and broadening participation in these fields. The vision of this program is to catalyze the STEM enterprise to work collaboratively for inclusive change, resulting in a STEM workforce that reflects the population of the Nation.

- The **Hispanic-Serving Institutions Program (HSI)** ($60.50 million) seeks to enhance the quality of undergraduate STEM education at HSIs and to increase retention and graduation rates of undergraduate students pursuing degrees in STEM fields at HSIs. The HSI program seeks to build capacity at HSIs that typically do not receive high levels of NSF grant funding.

- **Historically Black Colleges and Universities Excellence in Research (HBCU-EiR)** ($37.93 million) program supports projects that enable STEM and STEM education faculty to further develop research capacity at HBCUs and to conduct research.

- **Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)** ($48.50 million) is committed to enhancing the quality of undergraduate STEM education and research at HBCUs to broaden participation in the Nation's STEM workforce. HBCU-UP provides awards to

develop, implement, and study evidence-based innovative models and approaches for improving the success of HBCU undergraduates so that they may pursue STEM graduate programs and/or careers.

- The **Louis Stokes Alliances for Minority Participation (LSAMP)** ($70.50 million) is an alliance-based program that works to increase the number of STEM baccalaureate and graduate degrees awarded to populations historically underrepresented in STEM disciplines.

- The **Tribal Colleges and Universities Program (TCUP)** ($23.0 million) provides awards to Tribal Colleges and Universities, Alaska Native-serving institutions, and Native Hawaiian-serving institutions to promote high quality STEM education, research, and outreach.

- **Established Program to Stimulate Competitive Research (EPSCoR) Office** ($280.68 million) provides strategic programs and opportunities that stimulate sustainable improvements to EPSCoR jurisdictions' R&D capacity and capability. EPSCoR aims to stimulate research that enhances jurisdictional competitiveness in NSF disciplinary and multidisciplinary research programs, especially those that drive economic growth and geographic diversity. Also, pursuant to the CHIPS and Science Act, all NSF research divisions will commit additional support for meritorious proposals from EPSCoR jurisdictions.

- **Analytics for Equity Initiative** ($4.04 million) builds on the Evidence-Based Policymaking Act.[2] Led by NSF with four interagency partners, this program will fund researchers to produce rigorous empirical research and actionable recommendations in equity-related topics aligned to agency Learning Agendas[3]. Federal agencies and other organizations can use the resulting recommendations to increase the impact of equity-focused evidence-based strategies.

- **Graduate Research Fellowship Program** ($380.32 million) will support no less than 2,500 new fellows in FY 2024.

Research Infrastructure Theme

Research infrastructure (RI), from individual instruments to major research facilities, is foundational to the scientific endeavor. Definitions of RI have evolved significantly over the years, particularly as remote access and cyberinfrastructure have become essential components of almost every tool in use by the research community. The COVID-19 pandemic further emphasized the critical nature of these components and illustrated how they can enable ongoing efforts to expand access to RI to historically underserved groups and communities. Additionally, NSF investments in science and engineering have stimulated discovery and innovation in the design and development of novel infrastructure, giving rise to new and different forms of RI.

RI is a fundamental enabler of science and engineering advancement, of both ideas and people. Needed for all forms of fundamental research – from exploratory to solutions-oriented – RI investments enable advances in areas as varied as measurement of the evolution of carbon in the atmosphere, assessment of the rate at which glaciers are losing ice, analysis of the changes in biomass in forests, studies of the rate at which underrepresented groups are engaged in science and

[2] www.congress.gov/115/plaws/publ435/PLAW-115publ435.pdf

[3] www.evaluation.gov/evidence-plans/learning-agenda/

engineering disciplines, modeling of the epidemiology of infectious diseases, investigation of the fundamental structure of particles that make up everything in the universe, studies of biological, chemical, and physical processes at various timescales, and characterization of the contents of our solar system (including potentially hazardous asteroids). Catalyzed by the CHIPS and Science Act and by FY 2023 appropriations, investments in FY 2024 will support modernization of existing research infrastructure and the development of new infrastructure.

Support for **Major Facilities operations and maintenance (O&M**) ($1,069.80 million) continues to reflect a balance among multiple priorities. NSF divisions carefully allocate resources between research grants and O&M costs for research infrastructure. In addition to regular O&M needs to keep a facility functional, support for upgrades, significant periodic maintenance, and infrastructure renewal must also be addressed within Facilities O&M, which accounts for almost 10 percent of NSF's total request in FY 2024. NSF continues to explore ways to invest in research infrastructure, at all scales, to keep pace with changing technologies, increased demand by users, and expanding research opportunities.

The **Major Research Instrumentation (MRI)** ($92.75 million) program is responsible for catalyzing new knowledge and discoveries by helping STEM professionals acquire or develop the instrumentation needed for innovative science and engineering research. MRI grants support instrumentation in all NSF-supported research disciplines. In FY 2024, NSF will continue the implementation of CHIPS and Science Act provisions that began in FY 2023. These include waiving cost-sharing for new MRI projects and supporting projects for equipment and instrumentation to conserve or reduce the consumption of helium.

The **Mid-scale Research Infrastructure (Mid-scale RI)** ($155.06 million) program supports research infrastructure with a total project cost above the upper limit for the MRI program ($4.0 million) and below the Major Research Equipment and Facilities Construction (MREFC) threshold ($100.0 million). This dedicated funding line implements a high-priority, agency-wide mechanism that includes upgrades to major facilities as well as stand-alone projects.

The goals of the Mid-Scale RI program are to:

- Provide access to cutting-edge mid-scale research infrastructure, including instrumentation.
- Enable agile development and implementation of frontier scientific and engineering research infrastructure with a high potential to significantly advance the Nation's research capabilities.
- Train early-career scientists and engineers in the development and use of advanced research infrastructure.

In FY 2024, NSF investments will support Mid-scale RI Track-1 ($4.0 million to $20.0 million awards), funded through the Research & Related Activities account, and Track-2 ($20.0 million to $100.0 million awards), funded through the MREFC account. Both use an approximately biennial funding opportunity; the third solicitation for Mid-scale RI-1 (NSF 22-637[4]) was issued in FY 2022 and the second for Mid-scale RI-2 (NSF-21-537) in FY 2021, with awards in both planned for FY 2023. Subject to availability of funding in FY 2024, Mid-scale RI-1 will support projects from the FY 2022 competition and Mid-scale RI-2 will continue to support projects awarded from the first two competitions.

[4] www.nsf.gov/pubs/2022/nsf22637/nsf22637.htm

Major Research Equipment and Facilities Construction. Construction projects that require an investment of more than $100 million are generally supported in NSF's MREFC account. The FY 2024 Request includes funding for three ongoing projects -- the Antarctic Infrastructure Recapitalization program (an enduring program that replaces the Antarctic Infrastructure Modernization for Science or AIMS project), the two detector upgrades to operate at the High Luminosity-Large Hadron Collider (HL-LHC), and the Vera C. Rubin Observatory -- and the start of one new project -- the Leadership-Class Computing Facility (LCCF). The MREFC account also supports the Mid-scale RI Track 2 program, covering projects in the $20 million to $100 million range.

MREFC Account Funding, by Project

(Dollars in Millions)

	FY 2023 Estimate	FY 2024 Request
Antarctic Infrastructure Recapitalization (AIR)	$60.00	$60.00
HL-Large Hadron Collider Upgrade (HL-LHC)	33.00	38.00
Leadership-Class Computing Facility (LCCF)	-	93.00
Mid-scale Research Infrastructure, Track 2	76.25	105.06
Regional Class Research Vessel (RCRV)	1.98	-
Vera C. Rubin Observatory (Rubin)	15.00	7.61
Dedicated Construction Oversight	1.00	1.00
Total	**$187.23**	**$304.67**

NSF manages all U.S. Antarctic activities as a single, integrated program, making Antarctic research possible for scientists supported by NSF and other U.S. agencies. Impacts of the COVID-19 pandemic on U.S. Antarctic Program (USAP) operations required construction activities at McMurdo Station to be suspended and caused a significant delay to completion of AIMS. In the meantime, other investments in facilities and infrastructure on the continent have emerged as priorities that cannot be deferred until after completion of AIMS. As a result, the **Antarctic Infrastructure Recapitalization** (AIR) ($60.0 million) program was conceived as a portfolio of investments in infrastructure across the USAP stations that will replace AIMS. On-ice AIMS construction will continue in FY 2023 with a focus on meeting near-term needs, and unfunded parts of AIMS will be considered for incorporation into the longer-term AIR program. Some FY 2023 funding ($60.0 million) will be used to fund adjusted AIMS scope, if necessary, following a FY 2022 re-baseline of the project and the remainder will transition to a broader recapitalization of NSF's Antarctic infrastructure.

The Large Hadron Collider is the world's largest and highest energy particle accelerator. Located near Geneva, Switzerland and operated by the European Organization for Nuclear Research (CERN), LHC can accelerate and collide counter-propagating bunches of protons at a total energy of 14 tera-electron volts. A Toroidal LHC ApparatuS (ATLAS) and Compact Muon Solenoid (CMS) are two general purpose detectors used by researchers to observe these collisions and analyze their characteristics. In FY 2024, funding for **HL-LHC Upgrade** ($38.0 million) will support year four of the five-year project that began in FY 2020, prior to the onset of the COVID-19 pandemic. This investment will upgrade components of the ATLAS and CMS detectors, enabling them to function at much higher collision rates following an upgrade to the LHC to increase its luminosity. A re-baseline of the ATLAS and CMS upgrades will be conducted in FY 2023 to evaluate the impacts of the COVID-19 pandemic on the cost and schedule of the projects.

The **Regional Class Research Vessels** ($0.0), part of the U.S. Academic Research Fleet, are designed to meet the needs of researchers for work in coastal zones in support of biological, chemical, physical, and geological oceanography. The vessels will enable virtual participation of shore-based scientists using telepresence/data presence technology, greatly expanding the potential user base. The first of three vessels under construction is planned for delivery in 2023, with subsequent vessels being delivered six and twelve months thereafter. No additional funding is requested in FY 2024.

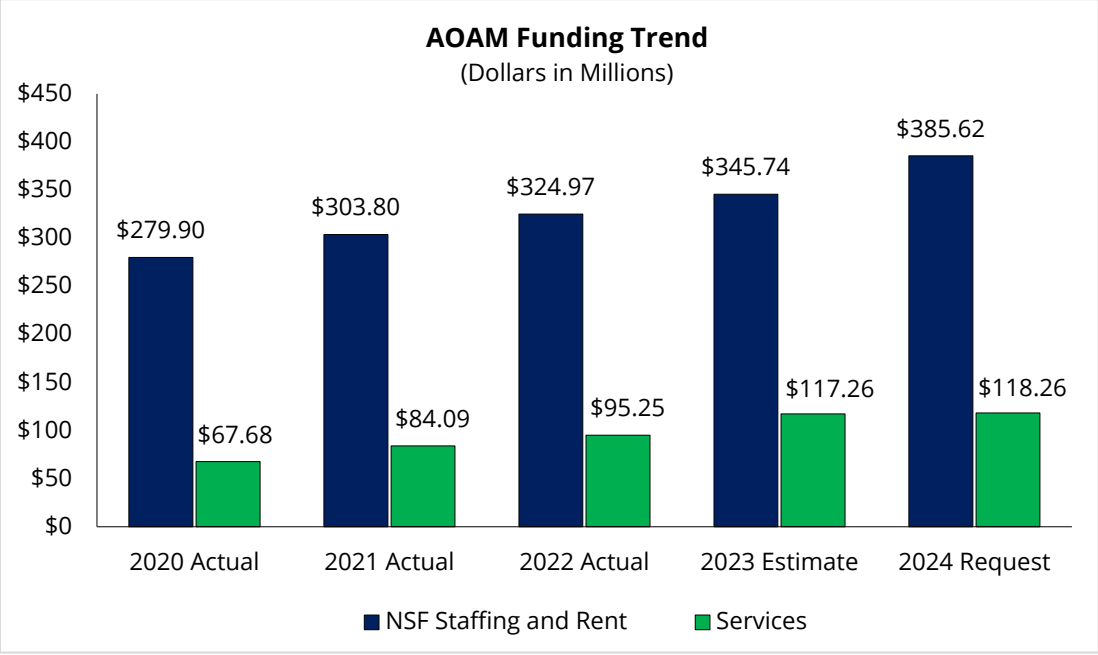
Vera C. Rubin Observatory ($7.61 million) will be an 8-meter-class wide-field optical telescope capable of carrying out surveys of the entire southern sky. It will collect nearly 40 terabytes of multi-color imaging data every night to produce the deepest, widest-field sky images ever. It will also issue alerts for moving and transient objects within 60 seconds of their discovery so that follow-up can be conducted by other optical and radio telescopes and gravitational-wave detectors. FY 2024 will be the eleventh and final year of funding, as the project comes to completion.

ORGANIZATIONAL EXCELLENCE - AGENCY OPERATIONS AND AWARD MANAGEMENT (AOAM)

The $11.314 billion in funding that NSF will support in FY 2024 is managed by the staff at NSF who enable research and steward the taxpayer investment. Investments in the Agency Operations and Award Management (AOAM) account provide the fundamental framework through which the Foundation's science and engineering research and education programs are administered. AOAM is the avenue by which NSF directly supports and responds to the Administration's management and performance priorities, including a growing research science and security framework vital to the well-being of the NSF-funded scientific enterprise. AOAM funds the essential services NSF needs to operate, and investments in the AOAM account continue to be an NSF priority.

In FY 2024, NSF requests a total of $503.87 million for AOAM, an increase of $40.87 million or 8.8 percent above FY 2023 Current Plan level for the AOAM account. Even with this large increase, NSF continues to operate as a lean agency with AOAM costs representing about 4.5 percent of NSF's total FY 2024 budget.

In the AOAM account, over three-quarters of the total AOAM funding covers NSF personnel and NSF's headquarters location in Alexandria, VA with the remaining quarter going to mission support services. Over the last several fiscal year budget requests, NSF reduced or held flat mission support services costs to accommodate the year-over-year increases in the fixed costs for staffing and rent while minimizing growth to the AOAM account in the Request. NSF then exercised its transfer authority to restore funding for those reduced activities.



In FY 2024 NSF is continuing its recent practice of requesting the AOAM amount NSF estimates it needs and is commensurate with the overall plans and priorities for NSF. The requested level will enable NSF to maintain a current services level of funding across its mission support activities while at the same time expand agency staffing needs, to effectively and efficiently meet the needs of a $11.3 billion federal research agency.

RESEARCH SECURITY STRATEGY AND POLICY

NSF is expanding capabilities and competencies to protect the U.S. science and engineering enterprise through its Research Security Strategy and Policy activity. In January 2022, the National Science and Technology Council's Research Security Subcommittee, which is co-chaired by NSF, issued implementation guidance for National Security Presidential Memorandum 33 (NSPM-33) on National Security Strategy for United States Government-Supported Research and Development. The August 2022 CHIPS and Science Act contained several research security provisions that NSF is implementing. NSF participation in discussions with the U.S. research community and with international colleagues, and development of common frameworks for understanding research security are major components of the NSF Research Security activity that is expected to continue to grow in FY 2024. Specific activities for FY 2024 include:

- Per the CHIPS and Science Act, to provide needed information and tools to the research community, NSF is established a Research Security and Integrity Information Sharing and Analysis Organization (RSI-ISAO). NSF will ramp up the capabilities of this organization to provide additional tools, information and resources in FY 2024.

- NSF will establish a Research on Research Security funding program in FY 2024 using guidance from the JASON study and an NSF-funded workshop. Primary goals of the program will include assessment of the characteristics that distinguish research security from research integrity, improving the quantitative understanding of the scale and scope of research security risks, developing methodologies to assess the potential impact of research security threats, and assessing the additional research security risks in an innovation system that includes more use-inspired research rather than staying well within the bounds of fundamental research.

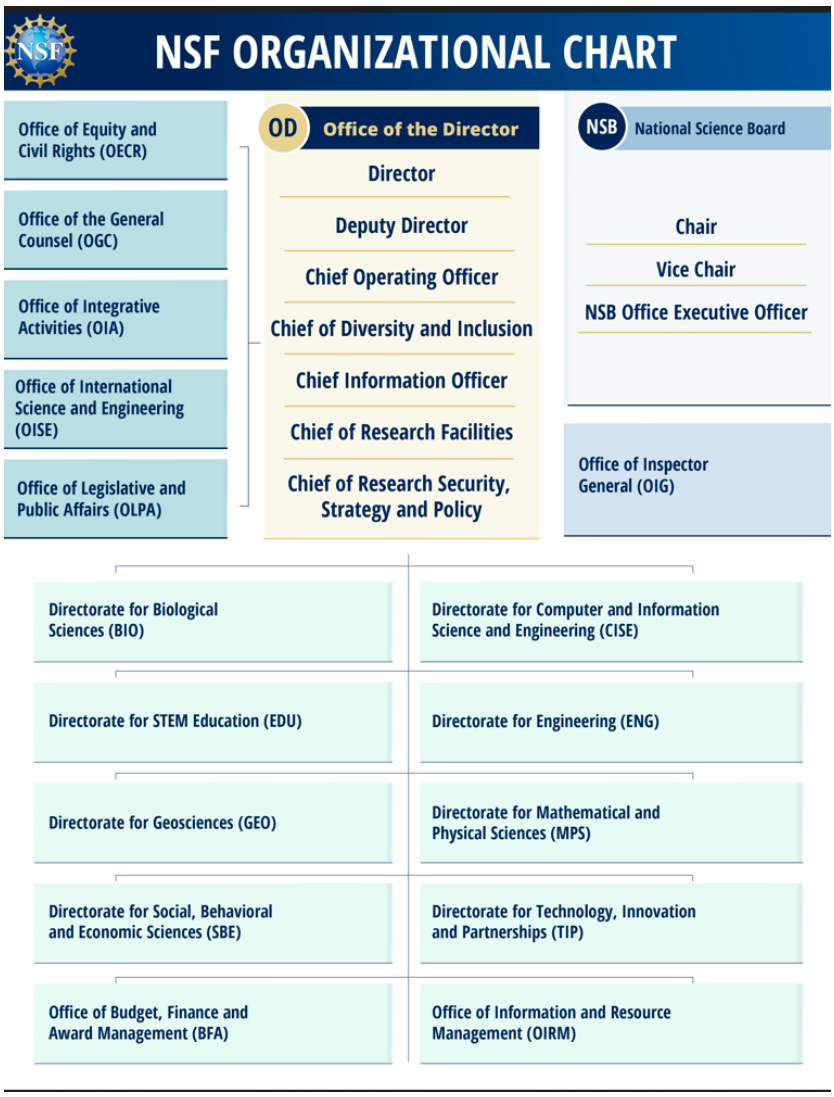
- Per the CHIPS and Science Act, NSF has established new analytic capabilities to proactively identify conflicts of commitment, vulnerabilities of pre-publication research, and risks to the merit review system. NSF will scale up the use of these analytics to analyze all NSF awards and contribute to NSF's SBIR due diligence process in FY 2024.

- Through a partnership with the federal government interagency community, NSF funded awards to develop research security training modules for the research community in FY 2023. These modules will be available by the beginning of FY 2024 and NSF will fund the delivery of these modules and their evaluation.

ORGANIZATION AND ROLE IN THE FEDERAL RESEARCH ENTERPRISE

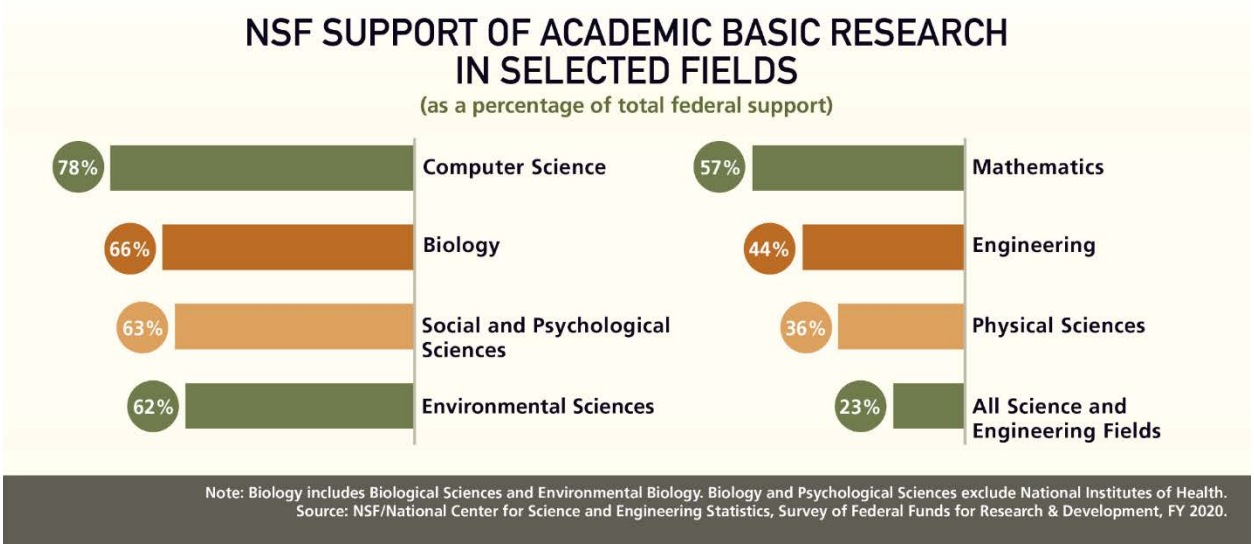
NSF's comprehensive and flexible support of meritorious projects enables the Foundation to identify and foster both fundamental and transformative discoveries and broader impacts within and among fields of inquiry. NSF has the latitude to support emerging fields, high-risk ideas, interdisciplinary collaborations, and research that pushes—and creates—the very frontiers of knowledge. In these ways, NSF's discoveries inspire the American public—and the world.

NSF's organization represents the major science and engineering fields, including biological sciences; computer and information science and engineering; engineering; geosciences; mathematical and physical sciences; and social, behavioral, and economic sciences. NSF also carries out specific responsibilities for education and human resources, integrative activities, and international science and engineering. The 25-member National Science Board approves the overall policies of NSF.

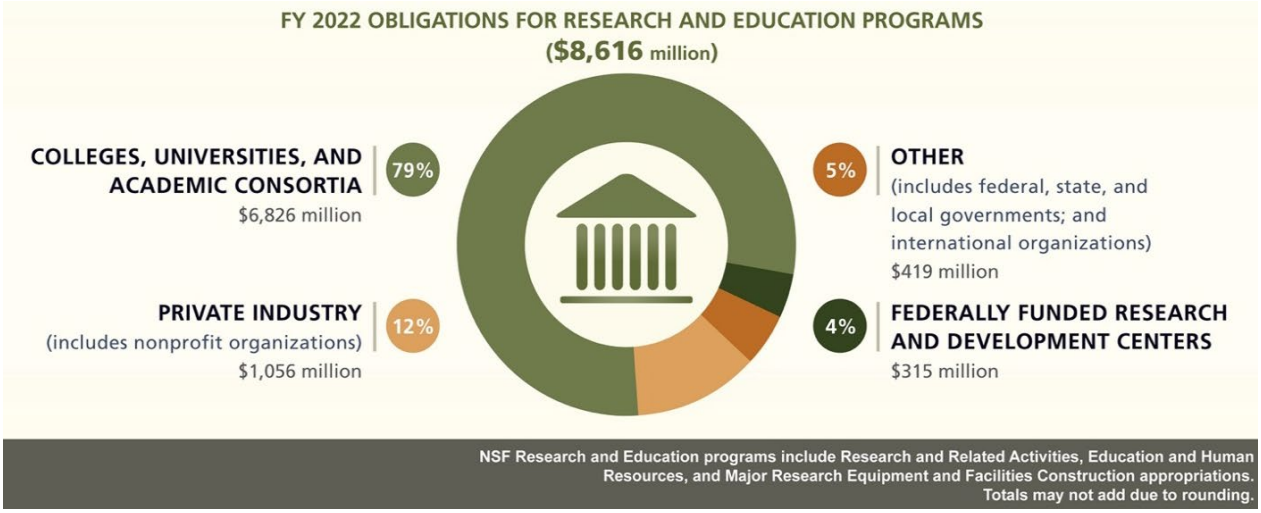


NSF BY THE NUMBERS

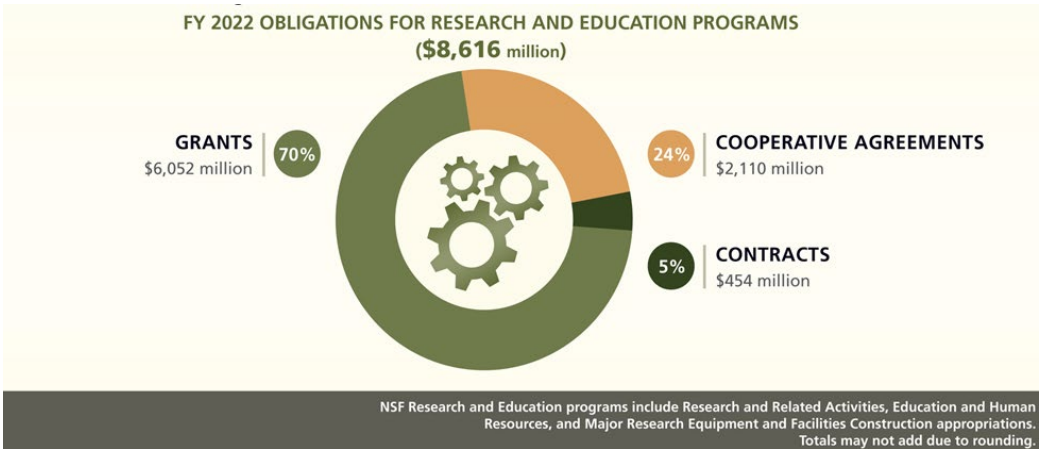
NSF's annual budget represents approximately 23 percent of the total federal budget for basic research conducted at U.S. colleges and universities. In many science and engineering fields, NSF is the primary source of federal academic support. In most major fields of science, NSF support of basic research at U.S. institutions is over 50 percent.



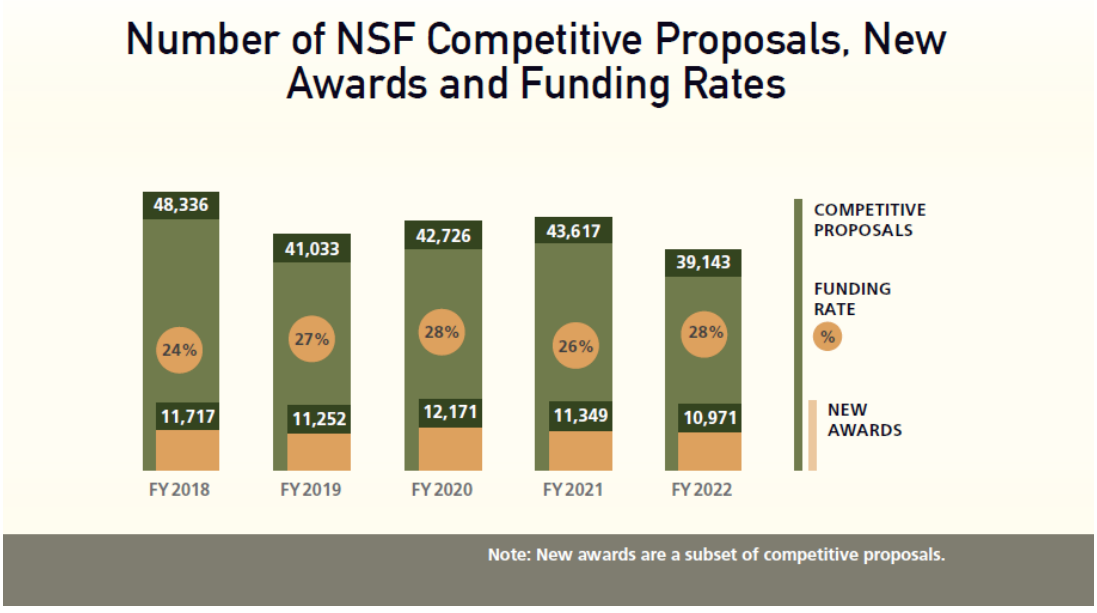
Most NSF awards are to academic institutions. In FY 2022, 79 percent of support for research and education programs ($6,826.0 million) was awarded to 822 different colleges, universities, and academic consortia. Private industry, including small businesses and non-profit organizations, accounted for 12 percent ($1,056.0 million), and support to Federally Funded Research and Development Centers accounted for 4 percent, or $315.0 million. Other recipients (federal, state, and local governments; and international organizations) received 5 percent ($419.0 million) of support for research and education programs. The distribution in FY 2024 is expected to be similar.



As shown below, 94 percent of NSF's FY 2022 projects were funded using grants or cooperative agreements. NSF grants are either standard or continuing awards. That is, the award is made during one fiscal year for the full amount of the award or made over several years in increments. Cooperative agreements are used when the project requires substantial agency involvement during the project performance. Contracts are used to acquire products, services, and studies required primarily for NSF or other government use. The distribution in FY 2024 is expected to be similar.



NSF continuously monitors key portfolio, proposal workload, and financial measures to understand short- and long-term trends and to help inform management decisions. The chart below presents a high-level, agency-wide estimate of funding rates, or proposal "success," as a comparison of the number of competitive proposals, new awards, and funding rate between FY 2018 and FY 2022. In FY 2024, NSF expects to evaluate over 46,500 proposals through a competitive merit review process and make over 12,900 new competitive awards, of which about 10,800 are expected to be new research grants and the remainder contracts and cooperative agreements.



HIGHLIGHTS

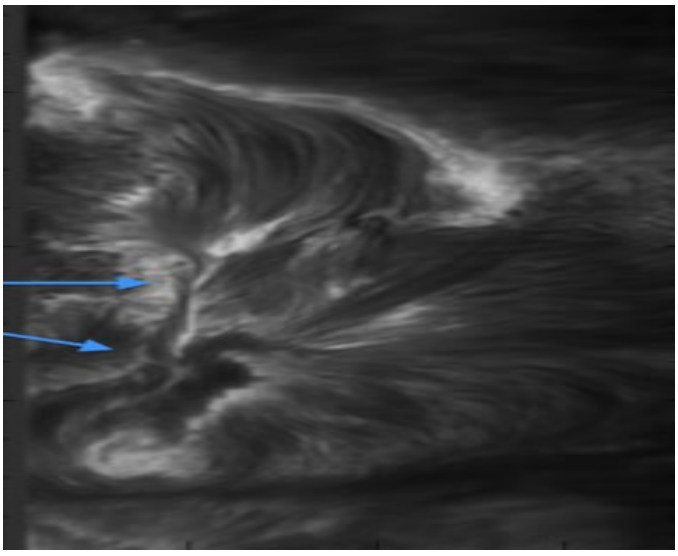
Research and Mentoring for Postbaccalaureates in Biological Sciences (RaMP)

Members of the RaMP program discuss research equipment. *Credit Michael Reichert*

Every year, millions of American students graduate with a degree in biology, but for some, it is hard to see a path forward toward a career in biotechnology, bioengineering, or other fields that require extensive research experience. This is especially true for individuals from groups underrepresented in STEM and first-generation college students, as well as for students at institutions with limited resources for research projects. To ensure talented students everywhere have the opportunity to join the STEM workforce and research community, NSF's Biological Sciences Directorate launched the Research and Mentoring for Postbaccalaureates in Biological Sciences program, known as RaMP. Based on research that shows how inclusive training, cohort-based mentoring, and personal networks can make a big difference in future career success, RaMP is helping colleges, universities, nonprofits, and other organizations build research opportunities that expand pathways into the biosciences for more students and help recent graduates get research experience that can boost their careers.

Magnetic reconnection breakthrough could help predict space weather

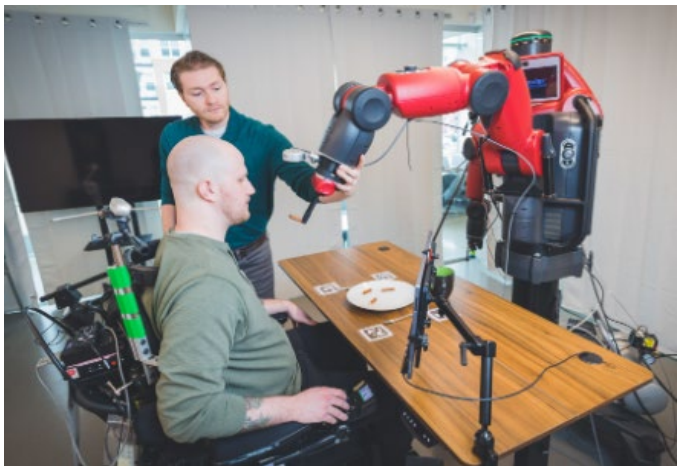
Space storms can wreak havoc on satellites and power grids, and magnetic reconnection plays a major role in the plasma eruptions on the sun's surface that spark space storms. NSF grantees at West Virginia University learned new information about magnetic reconnection and the physics of space-like plasmas by experimenting with lab-developed plasma. The research, part of the PHAse Space Mapping, or PHASMA, experiment, probed the plasma and light scattered from individual electrons in the plasma to assess how fast the particles were moving. PHASMA can accurately measure the motion and velocity of the ions and electrons on a very small scale, allowing the team to measure the actual speeds of individual electrons. The research will impact how space weather and solar storms are predicted and improve understanding of the universe's mechanics and dynamics.



The arrows point to a twisted filament, or magnetic flux rope, before magnetic reconnection occurs. *Credit: K. Reardon, NSF's National Solar Observatory and L. Kleint, University of Bern.*

NSF Research Traineeship Human-Machine Systems for Physical Rehabilitation

People with disabilities abandon assistive technologies at high rates, largely because their perspectives are not included in the development process. The NRT Program at Cleveland State University trains graduate students to work on transdisciplinary research teams in direct collaboration with the disability community. The goal is to ground new, accessible rehabilitation and assistive technologies in the unique perspectives and experiences of those living with disabilities. In the program, the students learn to span diverse perspectives in human-machine systems and develop human-centered approaches to research and design. This NRT program hopes to establish a new model for engineers, psychologists, and urban experts to collaborate with therapy professionals and the disability community to deliver future technologies for the most complex rehabilitation challenges.



A person controls a robot to feed himself. *Credit: Cleveland State University Center for Human-Machine Systems.*

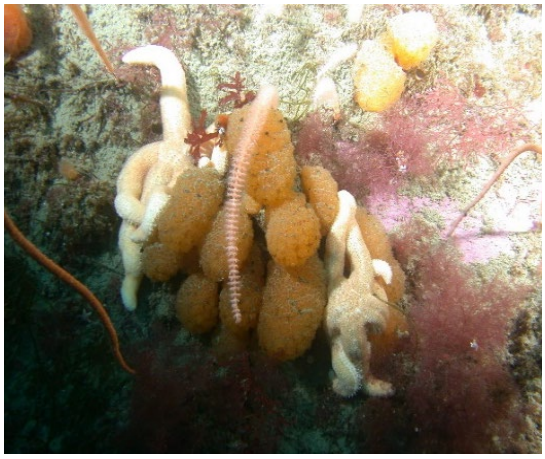
National Science Foundation announces multi-million dollar partnership with leading foundations to improve U.S. STEM education

Credit: NSF.

At the core of NSF's approach to accelerating discovery, innovation, and STEM education is a commitment to building strong partnerships across an array of agencies, industries, and organizations. That is why NSF, together with the Bill & Melinda Gates Foundation, Schmidt Futures, and Walton Family Foundation, have developed a new partnership to fund unique initiatives that will improve the quality of U.S. STEM education for all students, particularly those whose talents, intelligence, and entrepreneurship have been underutilized in the nation's STEM enterprise. This historic collaboration brings together some of the largest public and private funders committed to STEM education and is one of the first of its kind involving these organizations. NSF is proud to match the money from the foundations for each funded activity and help researchers answer some of the most pressing challenges in U.S.

Promising anti-melanoma properties discovered in a sea squirt

Researchers identified a compound produced by bacteria living on the sea floor near Antarctica that could be used to create a naturally derived treatment for melanoma. A team of NSF grantees from the Desert Research Institute at Los Alamos National Laboratory and the University of South Florida, traced the compound, palmerolide A, to a microbe that shares a symbiotic relationship with a species of ascidian, or sea squirt, common to the waters of Antarctica's Anvers Island archipelago. To survive, ascidians and other invertebrates developed relationships with microbes that play a role in photoprotective pigments, bioluminescence, and chemical defenses. The compounds produced by these microbes may also have other applications in science, health, and industry.



Synoicum adareanum pictured with a starfish in 80 feet of water near Bonaparte Point, Antarctica. *Credit: Bill J. Baker/Department of Chemistry, USF.*

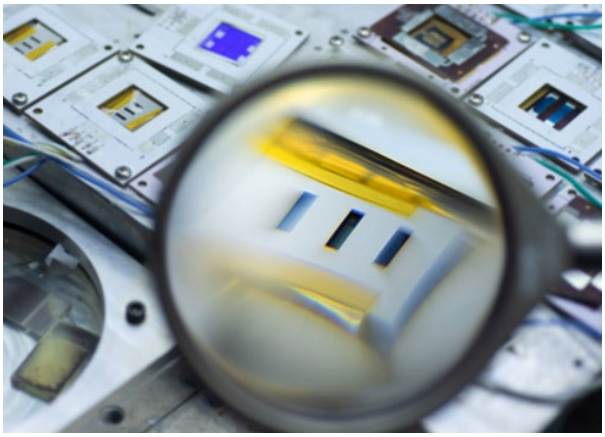
CIVIC Innovation Challenge

Mitigating the effects of disasters or bridging the gap between essential resources and services and nearby populations is the driving force behind the Civic Innovation Challenge. Led by NSF in partnership with the Department of Energy and Department of Homeland Security, researchers worked with civic partners to identify and address community challenges with research-based pilot projects. The two focus areas were resilience to natural disasters, and mobility and access to jobs and services. In the first stage, teams of local, state, and tribal officials as well as nonprofit and community leaders, refined the projects. In Stage 2, 11 disaster resiliency teams and six mobility teams received awards of up to $1 million to develop ready-to-implement pilot projects in a 12-month time frame. The solutions were also designed to become templates to address community issues across the U.S.

Map of Civic Innovation Challenge awards supporting community-based solutions. *Credit: NSF.*

New technology surpasses long-sought solar energy milestone

Engineers supported by NSF developed a new class of renewable solar energy technology that is as efficient as silicon-based solar cells but can be produced at lower cost and more sustainably. The new technology is based on perovskites, semiconductors that have a crystal structure compatible with solar cell technology – but that are also fragile and have a short lifespan. The team designed an accelerated aging process to improve testing and forecast long-term performance, and the perovskites can operate for nearly 30 years, a significant increase over the prior threshold of 20 years. As the technology becomes more efficient and long-lasting, competing designs will result in more durable and commercially viable technologies**.**



Engineers have developed an accelerated aging process to forecast long-term solar cell performance*. Credit: Bumper DeJesus.*

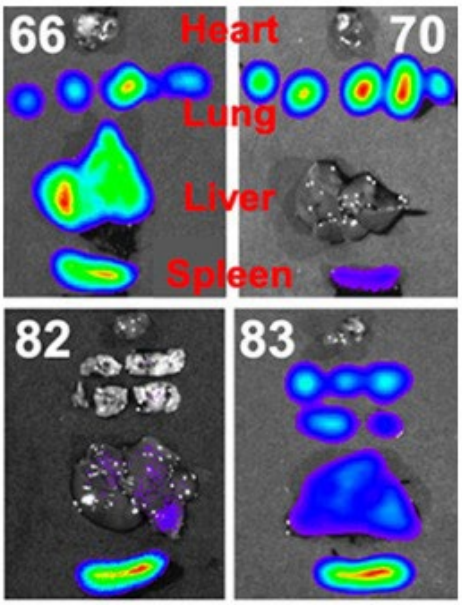
Low-cost, paper-based sensor conducts multiple tests at once

In medicine, diagnosing disease rapidly and reliably is a crucial first step in providing effective care. However, many communities lack the centralized infrastructure and trained personnel to perform these critical and costly tests. This disparity is driving researchers at the NSF-funded Precise Advanced Technologies and Health Systems for Underserved Populations (PATHS-UP) Engineering Research Center (ERC) to develop easy-to-read diagnostic tests constructed from paper. The new sensors developed by the PATHS-UP ERC employ a specially designed 'sensing membrane' that can detect dozens of diseases simultaneously while using only $0.30 worth of paper materials. And with simple operating steps, these tests can be performed in under 20 minutes with minimal training, helping bring critical healthcare access to underserved communities worldwide.

A multiplexed biomarker sensor that is quantified and read through a mobile phone for patient testing in clinical settings and even at home. *Credit: Ozcan Lab at UCLA.*

Targeted Delivery of mRNA with One-Component Ionizable Amphiphilic Janus Dendrimers

NSF investments are about to make mRNA vaccines more effective and easier to store. Designing mRNA vaccines, like those used to protect against COVID, is a complex process. One of the key tools is macromolecules, large and complex molecular structures that play a role in countless biological processes and are critical to mRNA vaccine delivery systems. Currently, all COVID vaccines require an assembly of four different macromolecules to ensure the vaccine works. But this combination of macromolecules is unstable, and therefore the vaccine needs to be stored at extremely low temperatures to be effective—and they don't always agree on the right temperature or solubility and therefore need to be stored at extremely low temperatures. That is about to change, though, thanks to NSF-funded researchers who have found a single new macromolecule that can replace all four currently being used. In addition to increasing stability and eliminating the need for ultra-cold storage, this revolutionary approach delivers the mRNA payload more efficiently and has the new capability to target specific organs. The major vaccine producers are already working to integrate this research into future production.



Representative images of mRNA delivery to different organs. *Credit: J. Am. Chem. Soc.*

From Yellowstone to Your Table

Nature's Fynd, formerly known as Sustainable Bioproducts, was initiated by a Montana State University postdoc and received initial funding from NSF in 2010. Nature's Fynd is committed to creating sustainably sourced food that is nutritious and tastes great such as vegan breakfast patties and dairy-free cream cheese. These foods are made using nutritional fungi proteins that originated in the hot springs of Yellowstone National Park. The company received Phase I NSF SBIR/STTR funding in 2013 and its products are now sold in Whole Foods markets in 10 states. The current valuation of Nature's Fynd is $1.75+ billion and the company has 100+ employees.

Bison grazing near Rose Creek in Lamar Valley. *Credit: NPS / Neal Herbert.*

Extreme weather research shows income impacts of Hurricane Katrina and Superstorm Sandy

A new analysis of the economic impacts of Hurricane Katrina and Superstorm Sandy could help improve climate resilience planning for cities anticipating severe weather events. While many studies have examined the storms' economic impacts through loss of business revenue, Illinois Institute of Technology social scientists focused on households' income and properties by looking at which populations saw the most economic harm from the storms and why. The researchers hope to understand how to mitigate future economic losses caused by extreme weather, especially among lower-income households.

Damage and destruction to houses in Biloxi, Mississippi, from Hurricane Katrina. *Credit: FEMA/Mark Wolfe.*

NSF and SRC partner to support semiconductor research experiences for undergraduates

The National Science Foundation and Semiconductor Research Corporation (SRC) recently signed a memorandum of understanding to support hands-on research opportunities for undergraduate students in research areas related to semiconductors. This partnership will advance the fundamental science and engineering of semiconductors and the development of a diverse science and engineering workforce for an area of high national priority. Under the new, five-year agreement, NSF and SRC will jointly support awards through the NSF Research Experiences for Undergraduates (REU) program for REU sites on semiconductor-related topics. In addition, to help introduce the industry perspective to faculty and students, SRC may invite awardees to share information with students about semiconductor industry career paths and conferences, to connect with representatives of SRC member companies, or to interact in other ways. Participating SRC member companies include Analog Devices, Arm, EMD Electronics, HRL-Boeing, IBM, Intel, MediaTek, Micron, Qorvo, Raytheon Technologies, Samsung, SK hynix, and TSMC.

REU student working with mentor and supervisor in the lab. *Credit: Arka Majumdar, University of Washington.*

NSF Programs help transform discoveries into cutting-edge solutions

Credit: NSF

NanoView Biosciences' journey shows how NSF's lab-to-market programs can help breakthrough technologies make the leap from research to commercialization. In 2011, NanoView Biosciences' cofounders received a Partnerships for Innovation grant to develop a prototype for diagnostic technology capable of rapidly detecting exosomes—messenger particles in blood, serum, and other samples that provide information about diseases. They completed NSF Innovation Corps™ training in 2013 and went on to receive a SBIR Phase I award in 2015, followed by a SBIR Phase II award in 2018. As its business grew, so did its technology, with new tools aimed at the rapidly expanding gene therapy sector. In 2022, NanoView Biosciences was acquired by Unchained Labs, a leading life sciences company. With help from three NSF programs, NanoView Biosciences was able to transform its research into cutting-edge solutions for gene therapy, biologics, and diagnostics.

Dimensional Energy, launched with the help of NSF's SBIR/STTR programs, produces sustainable aviation fuels. *Credit: Dimensional Energy.*

Recycling CO2 into sustainable aviation fuels

Dimensional Energy, launched with help from NSF's SBIR/STTR programs, known as America's Seed Fund, has developed a method to use sunlight to convert carbon dioxide into energy. Co-founded by two Cornell faculty members, the company gathers carbon dioxide from a sources like industrial sites (cement plants) or from direct-air capture, then adds renewable energy and hydrogen to their system of reactors, to transform it into an environmentally friendly fuel. The goal of the founders is to decarbonize the aviation industry with sustainable jet fuel and, in June 2022, United Airlines agreed to purchase at least 300 million gallons of their product over 20 years from the company.

National AI Research Institutes

As the primary non-defense federal funder of basic AI research, the U.S. National Science Foundation (NSF) is leading the Nation in making critical AI investments that will enable breakthroughs across nearly every sector of society, ensuring American health, wellbeing, and security.

Credit: Shutterstock/everything possible

SUMMARY TABLES

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

Total NSF Funding

STEM Education Investments

Research Infrastructure

NATIONAL SCIENCE FOUNDATION SUMMARY TABLE
FY 2024 BUDGET REQUEST TO CONGRESS

(Dollars in Millions)

NSF by Account	FY 2022 Actual[1]	FY 2023 Estimate Base[2]	Disaster Relief Supplemental: Base	Disaster Relief Supplemental: CHIPS and Science	Disaster Relief Supplemental: RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request REVISED	FY 2024 Request REVISED change over: FY 2022 Actual: Amount	FY 2022 Actual: Percent	FY 2023 Base Total[3]: Amount	FY 2023 Base Total[3]: Percent
BIO	$831.615	$831.73	$25.25	-	-	$856.98	$972.41	$140.80	16.9%	$115.43	13.5%
CISE	1,014.72	1,010.57	40.00	-	-	1,050.57	1,172.14	157.42	15.5%	121.57	11.6%
ENG	774.53	774.80	34.00	-	-	808.80	970.00	195.47	25.2%	161.20	19.9%
GEO	1,580.40	1,577.42	35.89	-	-	1,613.31	1,801.98	221.58	14.0%	188.67	11.7%
GEO: OPP	*544.68*	*545.16*	-	-	-	*545.16*	*565.60*	*20.92*	*3.8%*	*20.44*	*3.7%*
U.S. Antarctic Logistics Activities	*85.00*	*94.20*	-	-		*94.20*	*102.00*	*17.00*	*20.0%*	*7.80*	*8.3%*
MPS	1,615.26	1,612.90	70.44	-	2.50	1,685.84	1,835.79	220.53	13.7%	152.45	9.1%
SBE	285.86	285.82	27.38	-	-	313.20	360.60	74.74	26.1%	47.40	15.1%
TIP	413.09	450.00	220.00	210.00	-	880.00	1,185.63	772.54	187.0%	515.63	77.0%
SBIR/STTR, including Operations	*235.68*	*46.54*	*220.00*	-	-	*266.54*	*304.18*	*68.50*	*29.1%*	*37.64*	*14.1%*
OISE	54.23	61.32	8.00	-	-	69.32	71.21	16.98	31.3%	1.89	2.7%
IA	393.30	399.83	147.20	-	-	547.03	646.37	253.07	64.3%	99.34	18.2%
U.S. Arctic Research Commission	1.66	1.75	-	-	-	1.75	1.77	0.11	6.6%	0.02	1.1%
Research & Related Activities	**$6,964.66**	**$7,006.136**	**$608.16**	**$210.00**	**$2.50**	**$7,826.80**	**$9,017.90**	**$2,053.24**	**29.5%**	**$1,403.60**	**18.4%**
STEM Education	**$1,146.72**	**$1,154.00**	**$92.00**	**$125.00**	**-**	**$1,371.00**	**$1,496.18**	**$349.46**	**30.5%**	**$250.18**	**20.1%**
Major Res. Equip. & Fac. Construction[1]	**$120.60**	**$187.23**	**-**	**-**	**-**	**$187.23**	**$304.67**	**$184.07**	**152.6%**	**$117.44**	**62.7%**
Agency Operations & Award Mgmt.	**$420.21**	**$463.00**	**-**	**-**	**-**	**$463.00**	**$503.87**	**$83.66**	**19.9%**	**$40.87**	**8.8%**
Office of Inspector General	**$18.89**	**$23.39**	**-**	**-**	**-**	**$23.39**	**$26.810**	**$7.92**	**41.9%**	**$3.42**	**14.6%**
National Science Board	**$4.52**	**$5.09**	**-**	**-**	**-**	**$5.09**	**$5.25**	**$0.73**	**16.2%**	**$0.16**	**3.1%**
Total, NSF Discretionary Funding	**$8,675.61**	**$8,838.85**	**$700.16**	**$335.00**	**$2.50**	**$9,876.51**	**$11,354.68**	**$2,679.07**	**30.9%**	**$1,815.67**	**19.0%**
STEM Education - H-1B Visa	278.48	192.54	-	-	-	192.54	198.84	-79.64	-28.6%	6.30	3.3%
Donations	25.94	40.00	-	-	-	40.00	40.00	14.06	54.2%	-	-
Total, NSF Mandatory Funding	**$304.42**	**$232.54**	**-**	**-**	**-**	**$232.54**	**$238.84**	**-$65.58**	**-21.5%**	**$6.30**	**2.7%**
Total, NSF Budgetary Resources	**$8,980.03**	**$9,071.39**	**$700.16**	**$335.00**	**$2.50**	**$10,109.05**	**$11,593.52**	**$2,613.49**	**29.1%**	**$1,821.97**	**18.6%**

Totals exclude reimbursable amounts.

[1] Excludes $360.65 million provided by the American Rescue Plan supplemental appropriation and $23.45 million provided by the "Extending Government Funding and Delivering Emergency Assistance Act", for necessary expenses related to RCRV construction impacted by Hurricane Ida.

[2] Reflects the proposed transfer of $15.0 million from R&RA to AOAM as part of the Current Plan request, still pending prior to publication. This information differes from what is shown in the President's Budget Request which shows NSF's Enacted FY 2023 funding levels.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

NSF FUNDING PROFILE

The Funding Profile presents a high level, agency-wide estimate of proposal pressure, funding rates (or proposal "success"), and award statistics. These indicators are useful in gauging the relative impact of different funding levels.

Statistics for Competitive Awards: Competitive awards encompass the universe of NSF new activity in a given year. Examples include research grants, cooperative agreements, equipment, fellowships, and conferences.

Statistics for Research Grant Awards: Research Grant Awards are a sub-set of competitive awards. They are limited to research projects and exclude other categories of awards such as those for cooperative agreements, equipment, fellowships, and conferences.

The Number of Proposals is based on several factors, including past actual activity, planned competitions, and research trends within the various disciplinary communities. External factors, such as the state of the national economy and other sources of funding, also play a part. The Number of Awards is also based on several factors, including estimated funding and expected proposal pool. The Funding Rate is the number of awards made during a year as a percentage of total proposals competitively reviewed. This indicates the probability of receiving an award when submitting proposals to NSF. Annualized Award Size shows the annual level of research grant awards provided to awardees by dividing the total dollars of each award by the number of years over which it extends. Average Duration is the length of awards in years.

NSF Funding Profile[1]

	FY 2022 Actual Estimate	FY 2023 Base Estimate	FY 2024 Request Estimate
Statistics for Competitive Awards			
Number of Proposals	38,700	42,000	46,700
Number of Awards	10,900	11,200	12,900
Funding Rate	28%	27%	28%
Statistics for Research Grant Awards			
Number of Research Grant Proposals	32,100	37,000	40,900
Number of Research Grant Awards	8,700	9,400	10,800
Funding Rate	27%	25%	26%
Median Annualized Award Size	$164,700	$181,900	$185,600
Average Annualized Award Size	$214,500	$239,700	$245,800
Average Duration (years)	3.1	3.1	3.1

[1] Display excludes NSB, OIG, and staff offices.

NUMBER OF PEOPLE INVOLVED IN NSF ACTIVITIES

NSF estimates that in FY 2024 over 398,130 people will be directly involved in NSF programs and activities, receiving salaries, stipends, participant support, and other types of direct involvement. Beyond these figures, NSF programs indirectly impact millions of people, reaching K-12 students and teachers, the general public, and researchers through activities including workshops; informal science activities such as museums, television, videos, and journals; outreach efforts; and dissemination of improved curriculum and teaching methods.

Number of People Involved in NSF Activities

	FY 2022 Actual Estimate[1]	FY 2023 Base Estimate	FY 2024 Request Estimate
Senior Researchers	52,747	55,430	61,650
Other Professionals	13,473	14,300	16,040
Postdoctoral Associates	6,062	6,430	7,220
Graduate Students	43,615	45,530	51,270
Undergraduate Students	39,241	39,960	45,150
K-12 Teachers	41,862	42,200	48,900
K-12 Students	139,070	148,000	167,900
Total Number of People	**336,070**	**351,850**	**398,130**

[1] Does not include estimates for People funded through the American Rescue Plan supplemental appropriation.

Senior Researchers include scientists, mathematicians, engineers, and educators receiving funding through NSF awards. These include both researchers who are principal or co-principal investigators on research and education projects, and researchers working at NSF-supported centers and facilities.

Other Professionals are individuals who may or may not hold a doctoral degree or its equivalent, are considered professionals but are not reported as senior researchers, postdoctoral associates, or students. Examples are technicians, systems experts, etc.

Postdoctoral Associates are individuals who have received Ph.D., M.D., D.Sc., or equivalent and are not faculty members of the performing institution. These individuals are supported through funds included in research projects, centers, or facilities awards, as well as by postdoctoral fellowships.

Graduate Students include those compensated from NSF grant funds. NSF supports graduate students through NSF's fellowship and traineeship programs as well as research assistantships and funds to assist senior researchers or postdoctoral associates in performing research through awards for research projects, centers, or facilities. NSF provides support for approximately 26 percent of the U.S. science and engineering graduate students receiving federal funds and about four percent of the science and engineering graduate students in the U.S. overall.[1]

[1] NCSES Survey of Graduate Students and Postdoctorates in Science and Engineering: Fall 2021—Table 1-7: Detailed primary source of federal support for full-time graduate students in science, engineering, and health:

Undergraduate Students include students compensated from NSF grant funds who are enrolled in technical colleges or baccalaureate programs. They may be assisting senior researchers or postdoctoral associates in performing research, or participating in NSF programs aimed at undergraduate students, such as Research Experiences for Undergraduates.

K-12 Teachers include teachers at elementary, middle, and secondary schools. These individuals actively participate in intensive professional development experiences in the sciences and mathematics.

K-12 Students are those attending elementary, middle, and secondary schools. They are supported through program components that directly engage students in science and mathematics experiences.

1975–2021 (https://ncses.nsf.gov/pubs/nsf23312/assets/data-tables/tables/nsf23312-tab001-007.pdf); and Table 1-6: Primary source of support for full-time graduate students in science, engineering, and health: 1975–2021 (https://ncses.nsf.gov/pubs/nsf23312/assets/data-tables/tables/nsf23312-tab001-006.pdf)

NSF BUDGET REQUESTS AND APPROPRIATIONS BY ACCOUNT: FY 2000 - FY 2024

(Millions of Current Dollars)

Click here for complete history

	Research & Related Activities (R&RA)		STEM Education (EDU)[1]		Major Research Equipment & Facilities Construction (MREFC)[2]		Agency Operations & Award Management (AOAM)[3]		Office of Inspector General (OIG)		Office of the National Science Board (NSB)		NSF, TOTAL	
Fiscal Year	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation
2000	$3,004.00	$2,972.90	$678.00	$690.87	$85.00	$93.50	$149.00	$149.28	$5.45	$5.45	-	-	$3,921.45	$3,912.00
2001	3,540.68	3,356.29	729.01	785.60	138.54	121.33	157.89	161.09	6.28	6.27	-	-	4,572.40	4,430.57
2002	3,326.98	3,612.26	872.41	894.28	96.33	138.80	170.04	171.26	6.76	6.75	-	-	4,472.52	4,823.35
2003	3,783.21	4,069.29	908.08	903.17	126.28	148.54	210.16	189.43	8.06	9.19	-	3.48	5,035.79	5,323.09
2004	4,106.36	4,262.12	938.04	938.98	202.33	154.98	225.70	218.96	8.77	9.94	-	3.88	5,481.20	5,588.86
2005	4,452.31	4,229.98	771.36	841.42	213.27	173.65	294.00	223.45	10.11	10.03	3.95	3.97	5,745.00	5,482.49
2006	4,333.49	4,339.21	737.00	796.69	250.01	190.88	269.00	247.06	11.50	11.35	4.00	3.95	5,605.00	5,589.14
2007	4,665.95	4,654.24	816.22	796.59	240.45	175.61	281.82	248.50	11.86	10.97	3.91	3.97	6,020.21	5,889.87
2008	5,131.69	4,841.73	750.60	765.60	244.74	220.74	285.59	281.79	12.35	11.43	4.03	3.97	6,429.00	6,125.26
2009	*5,593.99*	*5,186.17*	*790.41*	*845.26*	*147.51*	*152.01*	*305.06*	*294.15*	*13.10*	*12.00*	*4.03*	*4.03*	*6,854.10*	*6,493.61*
2009 ARRA	-	*2,500.00*	-	*100.00*	-	*400.00*		-	-	*2.00*		-	-	*3,002.00*
2009 Total	5,593.99	7,686.17	790.41	945.26	147.51	552.01	305.06	294.15	13.10	14.00	4.03	4.03	6,854.10	9,495.61
2010	5,733.24	5,563.92	857.76	872.76	117.29	117.29	318.37	300.00	14.00	14.00	4.34	4.54	7,045.00	6,872.51
2011	6,018.83	5,509.98	892.00	861.03	165.19	117.06	329.19	299.40	14.35	13.97	4.84	4.53	7,424.40	6,805.98
2012	6,253.54	5,689.00	911.20	829.00	224.68	197.06	357.74	299.40	15.00	14.20	4.84	4.44	7,767.00	7,033.10
2013	5,983.28	5,543.72	875.61	833.31	196.17	196.17	299.40	293.60	14.20	13.19	4.44	4.12	7,373.10	6,884.11
2014	6,212.29	5,808.92	880.29	846.50	210.12	200.00	304.29	298.00	14.32	14.20	4.47	4.30	7,625.78	7,171.92
2015	5,807.46	5,933.65	889.75	866.00	200.76	200.76	338.23	325.00	14.43	14.43	4.37	4.37	7,255.00	7,344.21
2016	6,186.30	5,989.68	962.57	878.97	200.31	218.31	354.84	357.00	15.16	15.16	4.37	4.37	7,723.55	7,463.49
2017	6,425.44	6,005.65	952.86	873.05	193.12	214.86	373.02	359.09	15.20	15.20	4.38	4.37	7,964.02	7,472.22
2018[4]	5,361.65	6,334.48	760.55	902.00	182.80	182.80	328.51	328.51	15.01	15.20	4.37	4.37	6,652.89	7,767.36
2019	6,150.68	6,504.51	873.37	922.00	94.65	295.74	333.63	333.03	15.35	15.35	4.32	4.37	7,472.00	8,075.00
2020[5]	5,662.96	6,789.80	823.47	942.55	223.23	243.23	336.89	357.75	15.35	16.50	4.10	4.50	7,066.00	8,354.33
2021[6]	6,213.02	7,347.48	930.93	1,029.00	229.75	301.00	345.64	386.93	17.85	17.85	4.21	4.50	7,741.40	9,086.76
2022[7]	8,139.71	6,999.52	1,287.27	1,149.46	249.00	240.52	468.30	424.90	20.42	19.00	4.60	4.60	10,169.30	8,838.00
2023 Estimate[8]	8,425.99	7,614.30	1,377.18	1,246.00	187.23	187.23	473.20	463.00	23.39	23.39	5.09	5.09	10,492.08	9,539.01
2024 Request REVISED	9,017.90	-	1,496.18	-	304.67	-	503.87	-	26.81	-	5.25	-	11,354.68	-

Totals may not add due to rounding. Appropriations as shown are after supplemental appropriations, transfers, and reprogrammings.

[1] The STEM Education (EDU) account was previously known as Education and Human Resources (EHR) until FY 2023.

[2] The Major Research Equipment and Facilities Construction (MREFC) account was known as Major Research Equipment (MRE) until FY 2002.

[3] The Agency Operations and Award Management (AOAM) account was known as Salaries & Expenses (S&E) until FY 2008.

[4] FY 2018 appropriations include Additional Supplemental Appropriations for Disaster Relief Requirements Act of 2018 supplemental appropriations (P.L. 115-123), which provided NSF $16.30 million in no-year funding to repair radio observatory facilities damaged by hurricanes that occurred during 2017.

[5] FY 2020 appropriations includes Coronavirus Aid, Relief, and Economic Security Act (CARES Act) supplemental appropriations (P.L. 116-136), which provided NSF $76.0 million in two-year funding ($75.0 million to the R&RA account and $1.0 million to the AOAM account) to prevent, prepare for, and respond to coronavirus, domestically or internationally, including to fund research grants and other necessary expenses. NSF subsequently transferred $5.0 million from the R&RA account to the EHR account for these purposes.

[6] FY 2021 Appropriations exclude the $600.0 million in American Rescue Plan Act of 2021 (ARP) (P.L. 117-2) supplemental two-year appropriations to fund or extend new and existing research grants, cooperative agreements, scholarships, fellowships, and apprenticeships, and related administrative expenses to prepare for, and respond to coronavirus.

[7] MREFC account level excludes $25.0 million in one-time funding for necessary expenses related to RCRV construction impacted by Hurricane Ida as provides in P.L. 117-43, the "Extending Government Funding and Delivering Emergency Assistance Act."

[8] Captures base funds provided by the FY 2023 Omnibus appropriation at $8,838.849 million and the Disaster Relief Supplemental (DRS) base at $700.162 million. Not captured is an additional $337.50 million provided by DRS in the R&RA and EDU Accounts for implementation of CHIPS and Science Act activities and for the mitigation of damage to research facilities and scientific equipment.

NSF ADMINISTRATION PRIORITIES AND CROSSCUTTING RESEARCH TOPICS SUMMARY
FY 2024 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	Advanced Manufacturing							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$7.16	$7.16	-	-	$7.16	$7.16	-	-
CISE	45.24	44.30	-	-	44.30	44.40	0.10	0.2%
ENG	129.00	125.00	-	-	125.00	184.37	59.37	47.5%
GEO Programs	-	-	-	-	-	-	-	N/A
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	162.30	128.33	-	-	128.33	133.33	5.00	3.9%
SBE	0.50	0.50	-	-	0.50	3.50	3.00	600.0%
TIP	54.00	27.94	13.66	13.04	54.64	73.60	32.00	76.9%
OISE	0.02	0.50	-	-	0.50	0.50	-	-
IA	15.60	1.00	-	-	1.00	1.00	-	-
R&RA	**$413.82**	**$334.73**	**$13.66**	**$13.04**	**$361.43**	**$447.86**	**$99.47**	**28.6%**
EDU	**12.37**	**6.00**	**-**	**-**	**6.00**	**6.00**	**-**	**-**
Total, NSF	**$426.19**	**$340.73**	**$13.66**	**$13.04**	**$367.43**	**$453.86**	**$99.47**	**28.1%**

[1] FY 2022 Actual are greater than future fiscal years due to the receipt of more meritorious proposals than expected.

	Advanced Wireless							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	-	-	-	-	-	-	-	N/A
CISE	89.45	88.76	-	-	88.76	93.26	4.50	5.1%
ENG	26.00	25.00	-	-	25.00	27.75	2.75	11.0%
GEO Programs	-	-	-	-	-	-	-	N/A
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	17.00	17.00	-	-	17.00	17.00	-	-
SBE	-	-	-	-	-	-	-	N/A
TIP	30.00	15.62	7.64	7.29	30.55	41.16	17.90	77.0%
OISE	-	-	-	-	-	-	-	N/A
IA	-	-	-	-	-	-	-	N/A
R&RA	**$162.45**	**$146.38**	**$7.64**	**$7.29**	**$161.31**	**$179.17**	**$25.15**	**16.3%**
EDU	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**N/A**
Total, NSF	**$162.45**	**$146.38**	**$7.64**	**$7.29**	**$161.31**	**$179.17**	**$25.15**	**16.3%**

[1] FY 2022 Actual are greater than future fiscal years due to the receipt of more meritorious proposals than expected.

	Artificial Intelligence							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$20.00	$20.00	-	-	$20.00	$20.00	-	-
CISE	346.96	344.00	-	-	344.00	389.00	45.00	13.1%
ENG	88.00	88.00	-	-	88.00	97.00	9.00	10.2%
GEO Programs	1.00	5.00	-	-	5.00	5.00	-	-
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	134.18	75.21	-	-	75.21	84.20	8.99	12.0%
SBE	17.74	16.92	-	-	16.92	19.59	2.67	15.8%
TIP	100.00	52.45	25.64	24.48	102.57	138.19	60.10	77.0%
OISE	-	-	-	-	-	-	-	N/A
IA	14.30	1.00	-	-	1.00	1.00	-	-
R&RA	**$722.18**	**$602.58**	**$25.64**	**$24.48**	**$652.70**	**$753.98**	**$125.76**	**20.0%**
EDU	**59.61**	**35.00**	**-**	**-**	**35.00**	**42.50**	**7.50**	**21.4%**
Total, NSF	**$781.79**	**$637.58**	**$25.64**	**$24.48**	**$687.70**	**$796.48**	**$133.26**	**20.1%**

[1] FY 2022 Actual are greater than future fiscal years due to the receipt of more meritorious proposals than expected.

	Biotechnology							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$118.00	$122.75	$25.25	-	$148.00	$176.88	$28.88	19.5%
CISE	9.65	6.92	-	-	6.92	6.92	-	-
ENG	92.00	92.00	-	-	92.00	106.50	14.50	15.8%
GEO Programs	10.00	10.00	-	-	10.00	10.00	-	-
GEO: OPP	1.60	1.60	-	-	1.60	2.00	0.40	25.0%
MPS	75.63	62.20	-	-	62.20	62.20	-	-
SBE	1.68	1.50	-	-	1.50	1.50	-	-
TIP	30.00	35.31	17.27	16.48	69.06	93.05	40.47	77.0%
OISE	-	-	-	-	-	-	-	N/A
IA	22.52	1.00	-	-	1.00	1.00	-	-
R&RA	**$361.08**	**$333.28**	**$42.52**	**$16.48**	**$392.28**	**$460.05**	**$84.25**	**22.4%**
EDU	**9.37**	**9.00**	**-**	**-**	**9.00**	**10.00**	**1.00**	**11.1%**
Total, NSF	**$370.45**	**$342.28**	**$42.52**	**$16.48**	**$401.28**	**$470.05**	**$85.25**	**22.2%**

NSF ADMINISTRATION PRIORITIES AND CROSSCUTTING RESEARCH TOPICS SUMMARY
FY 2024 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	NSTC Crosscut Quantum Information Science							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$3.28	$3.28	-	-	$3.28	$3.28	-	-
CISE	25.03	20.70	-	-	20.70	24.74	4.04	19.5%
ENG	31.17	29.50	-	-	29.50	32.89	3.39	11.5%
GEO Programs	-	-	-	-	-	-	-	N/A
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	229.87	179.00	-	-	179.00	214.00	35.00	19.6%
SBE	-	-	-	-	-	-	-	N/A
TIP	25.00	19.65	9.60	9.18	38.43	51.76	22.51	77.0%
OISE	-	1.00	-	-	1.00	1.00	-	-
IA	19.36	-	-	-	-	-	-	N/A
R&RA	**$333.71**	**$253.13**	**$9.60**	**$9.18**	**$271.91**	**$327.67**	**$64.94**	**24.7%**
EDU	**14.08**	**4.00**	**-**	**-**	**4.00**	**5.00**	**1.00**	**25.0%**
Total, NSF	**$347.79**	**$257.13**	**$9.60**	**$9.18**	**$275.91**	**$332.67**	**$65.94**	**24.7%**

[1] FY 2022 Actual are greater than future fiscal years due to the receipt of more meritorious proposals than expected.

	Microelectronics and Semiconductors							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$3.00	-	-	-	-	-	-	N/A
CISE	41.00	40.00	-	-	40.00	40.00	-	-
ENG	43.00	43.00	-	-	43.00	63.00	20.00	46.5%
GEO Programs	-		-	-	-	-	-	N/A
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	50.96	31.00	-	-	31.00	33.00	2.00	6.5%
SBE	-	-	-	-	-	-	-	N/A
TIP	15.00	25.69	12.56	11.99	50.24	67.68	29.43	76.9%
OISE	-	-	-	-	-	-	-	N/A
IA	-	-	-	-	-	-	-	N/A
R&RA	**$152.96**	**$139.69**	**$12.56**	**$11.99**	**$164.24**	**$203.68**	**$51.43**	**33.8%**
EDU	**-**	**-**	**-**	**-**	**-**	**6.00**	**6.00**	**N/A**
Total, NSF	**$152.96**	**$139.69**	**$12.56**	**$11.99**	**$164.24**	**$209.68**	**$57.43**	**37.7%**

	NSTC Crosscut Clean Energy Technology							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$50.00	$55.00	-	-	$55.00	$74.50	$19.50	35.5%
CISE	29.28	39.50	-	-	39.50	39.50	-	-
ENG	150.00	163.00	30.00	-	193.00	229.75	36.75	19.0%
GEO Programs	-	-	-	-	-	-	-	N/A
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	123.08	123.83	-	-	123.83	123.57	-0.26	-0.2%
SBE	-	-	-	-	-	-	-	N/A
TIP	49.20	39.95	13.12	12.52	65.59	70.69	17.62	33.2%
OISE	17.05	7.50	-	-	7.50	12.50	5.00	66.7%
IA	0.14	-	-	-	-	-	-	N/A
R&RA	**$418.75**	**$428.78**	**$43.12**	**$12.52**	**$484.42**	**$550.51**	**$78.61**	**16.7%**
EDU	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**N/A**
Total, NSF	**$418.75**	**$428.78**	**$43.12**	**$12.52**	**$484.42**	**$550.51**	**$78.61**	**16.7%**

	NSTC Crosscut U.S. Global Change Research Program							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request REVISED	Amount	Percent
BIO	$162.01	$211.71	-	-	$211.71	$225.07	$13.36	6.3%
CISE	-	-	30.00	-	30.00	30.00	-	-
ENG	-	-	-	-	-	50.00	50.00	N/A
GEO Programs	337.60	345.60	10.00	-	355.60	479.46	123.86	34.8%
GEO: OPP	236.00	197.26	-	-	197.26	197.26	-	-
MPS	13.44	12.00	-	-	12.00	14.63	2.63	21.9%
SBE	19.92	20.00	-	-	20.00	25.14	5.14	25.7%
TIP	-	-	-	-	-	-	-	N/A
OISE	11.99	7.50	8.00	-	15.50	12.50	-3.00	-19.4%
IA	-	-	2.00	-	2.00	1.00	-1.00	-50.0%
R&RA	**$780.96**	**$794.07**	**$50.00**	**-**	**$844.07**	**$1,035.06**	**$190.99**	**22.6%**
EDU	**-**	**-**			**-**		**-**	**N/A**
Total, NSF	**$780.96**	**$794.07**	**$50.00**	**-**	**$844.07**	**$1,035.06**	**$190.99**	**22.6%**

NSF ADMINISTRATION PRIORITIES AND CROSSCUTTING RESEARCH TOPICS SUMMARY
FY 2024 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	NSTC Crosscut National Nanotechnology Initiative (NNI)							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$39.95	$39.95	-	-	$39.95	$39.95	-	-
CISE	15.62	14.05	-	-	14.05	14.05	-	-
ENG	267.13	190.95	-	-	190.95	231.75	$40.80	21.4%
GEO Programs	-	-	-	-	-	-	-	N/A
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	206.17	126.00	-	-	126.00	126.00	-	-
SBE	0.40	0.40	-	-	0.40	0.40	-	-
TIP	4.90	5.15	2.51	2.39	10.05	13.54	$5.88	76.8%
OISE	0.10	0.10	-	-	0.10	0.10	-	-
IA	-	-	-	-	-	-	-	N/A
R&RA	**$534.27**	**$376.60**	**$2.51**	**$2.39**	**$381.50**	**$425.79**	**$46.68**	**12.3%**
EDU	**10.85**	**2.50**	**-**	**-**	**2.50**	**2.50**	**-**	**-**
Total, NSF	**$545.12**	**$379.10**	**$2.51**	**$2.39**	**$384.00**	**$428.29**	**$46.68**	**12.2%**

[1] FY 2022 Actual are greater than future fiscal years due to the receipt of more meritorious proposals than expected.

	NSTC Crosscut Networking & Information Technology R&D (NITRD)							
			Disaster Relief Supplemental				FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS+ Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIO	$79.00	$79.00	-	-	$79.00	$81.50	$2.50	3.2%
CISE	1,015.57	1,010.57	40.00	-	1,050.57	1,172.14	121.57	11.6%
ENG	167.42	156.45	-	-	156.45	179.26	22.81	14.6%
GEO Programs	23.00	27.00	-	-	27.00	30.00	3.00	11.1%
GEO: OPP	-	-	-	-	-	-	-	N/A
MPS	345.76	224.15	-	-	224.15	239.34	15.19	6.8%
SBE	41.89	30.94	2.00	-	32.94	38.94	6.00	18.2%
TIP	224.10	196.13	95.91	91.53	383.57	516.76	224.72	76.9%
OISE	-	-	-	-	-	-	-	N/A
IA	14.30	1.00	-	-	1.00	1.00	-	-
R&RA	**$1,911.04**	**$1,725.24**	**$137.91**	**$91.53**	**$1,954.68**	**$2,258.94**	**$395.79**	**21.2%**
EDU	**17.65**	**22.09**	**-**	**-**	**22.09**	**22.09**	**-**	**-**
Total, NSF	**$1,928.69**	**$1,747.33**	**$137.91**	**$91.53**	**$1,976.77**	**$2,281.03**	**$395.79**	**21.0%**

NSF PROGRAMS TO BROADEN PARTICIPATION

NSF has taken a variety of approaches to broaden participation across its many programs. While broadening participation is included in the NSF review criteria, some program announcements and solicitations go beyond the standard criteria. They range from encouraging language to specific requirements. Investments range from capacity building, research centers, partnerships, and alliances to the use of co-funding or supplements to existing awards in the core research programs.

NSF's broadening participation portfolio can be divided into three categories: (1) Focused, (2) Emphases, and (3) Geographic Diversity. The following sections define each of these categories and provide a list of the programs and activities with their respective funding levels that comprise each.

(Dollars in Millions)

			Disaster Relief Supplemental				Change Over	
	FY 2022 Actuals[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request REVISED	FY 2023 Base Total[2] Amount	Percent
Total, Broadening Participation Programs[3]	**$1,374.24**	**$1,453.82**	**$141.44**	**$72.07**	**$1,667.33**	**$1,843.16**	**$247.90**	**15.5%**

[1] FY 2022 Actual levels do not include funds provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[3] Totals exclude H-1B Visa funded programs (S-STEM and ITEST).

Focused Programs

Focused Programs have broadening participation as an explicit goal of the program and are included at 100 percent of their funding.

(Dollars in Millions)

				Disaster Relief Supplemental				Change Over	
		FY 2022 Actuals[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	FY 2023 Base Total[2] Amount	Percent
Focused Programs[3]									
ADVANCE	EDU	$18.50	$19.00	-	$2.00	$21.00	$22.33	$3.33	17.5%
Advancing Informal STEM Learning (AISL)	EDU	65.50	70.00	-	16.00	86.00	80.00	10.00	14.3%
Alliances for Graduate Education & the Professoriate (AGEP)	EDU	8.50	9.50	-	3.00	12.50	15.50	6.00	63.2%
AGEP Graduate Research Supplements (AGEP-GRS)	RRA	4.82	3.74	-	-	3.74	4.64	0.90	24.1%
Broadening Participation in Biology Fellowships	RRA	3.45	8.00	-	-	8.00	10.50	2.50	31.3%
Broadening Participation in Engineering (BPE)	RRA	6.00	7.50	-	-	7.50	9.00	1.50	20.0%
Career-Life Balance (CLB)[4]	RRA	1.99	0.28	-	-	0.28	0.73	0.45	160.7%
Centers of Research Excellence in Science & Technology (CREST)	EDU	26.01	29.00	-	3.00	32.00	41.00	12.00	41.4%
CISE Education and Workforce	RRA	15.65	14.75	-	-	14.75	16.75	2.00	13.6%
CISE Graduate Fellowships (CSGrad4US)	RRA	-	8.50	-	-	8.50	12.50	4.00	47.1%
CISE-MSI Research Expansion Program	RRA	3.07	7.00	-	-	7.00	12.00	5.00	71.4%
Disability and Rehabilitation Engineering (DARE)	RRA	5.66	5.10	-	-	5.10	6.00	0.90	17.6%
Eddie Bernice Johnson INCLUDES Initiative (INCLUDES Initiatve)	EDU	23.01	30.00	-	5.00	35.00	50.50	20.50	68.3%
Excellence Awards in Science & Engineering (EASE)[5]	EDU	4.11	7.40	-	-	7.40	8.00	0.60	8.1%
ExpandAI	RRA	-	7.00	-	-	7.00	10.00	3.00	42.9%
ExpandQISE	RRA	-	18.00	-	-	18.00	10.00	-8.00	-44.4%
Growing Resch Access for Nation'ly Transformative Equity & Diversity (GRANTED)	RRA	-	34.18	10.82	-	45.00	50.00	5.00	11.1%
HBCU Excellence in Research (HBCU-EiR)	RRA	18.78	10.00	15.00	-	25.00	37.93	12.93	51.7%
Historically Black Colleges & Universities Undergrad Prog (HBCU-UP)	EDU	38.01	43.00	-	3.00	46.00	48.50	5.50	12.8%
IUSE: Hispanic Serving Institutions (HSI) Program	EDU	48.50	53.50	-	2.00	55.50	60.50	7.00	13.1%
Louis Stokes Alliances for Minority Participation (LSAMP)	EDU	51.52	55.50	-	-	55.50	70.50	15.00	27.0%
MPS Ascending Postdoctoral Research Fellowships (MPS-Acend)	RRA	0.72	10.00	-	-	10.00	30.00	20.00	200.0%
MPS Partnerships for Research & Education	RRA	9.73	12.50	-	-	12.50	32.50	20.00	160.0%
NSF Scholarships in STEM (S-STEM)	EDU	[243.70]	[144.41]	-	-	[144.41]	[149.13]	[4.72]	[3.3%]
Resch and Mentoring for Postbaccalaureates in Biological Sciences (RaMP)	RRA	32.47	30.00	-	-	30.00	49.10	19.10	63.7%
SBE Build and Broaden	RRA	8.01	8.00	-	-	8.00	18.06	10.06	125.8%
SBE Postdoctoral Research Fellowships-Broadening Participation	RRA	1.49	1.50	1.50	-	3.00	6.00	3.00	100.0%
Science of Broadening Participation	RRA	1.50	1.50	-	-	1.50	2.73	1.23	82.0%
Tribal Colleges & Universities Program (TCUP)	EDU	17.50	20.00	-	6.00	26.00	23.00	3.00	15.0%
Subtotal, Focused Programs		**$414.50**	**$524.45**	**$27.32**	**$40.00**	**$591.77**	**$738.27**	**$186.50**	**33.8%**

[1] FY 2022 Actual levels do not include funds provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[3] Totals exclude H-1B Visa funded programs (S-STEM and ITEST).

[4] NSF continues to support the Career-Life Balance Initiative through supplemental funding to active NSF awards. In general, CLB funding will be reported annually as part of NSF's actual obligations.

[5] EASE comprises both Presidential Awards for Excellence in Science, Math, and Engineering Mentoring and Presidential Awards for Excellence in Mathematics and Science Teaching.

Emphasis Programs

Emphasis Programs have broadening participation as one of several emphases, but broadening participation is not an explicit goal of the program. These programs are included at a percentage of their funding level. The percentage used equals the 3-year average percentage of the programs' award portfolio that meets one the following criteria where an award:

- Was to a Minority Serving Institution (MSI);
- Had at least 50 percent of its principal investigators from an underrepresented group; or
- Had at least 50 percent of the students or postdocs supported by the grant reporting themselves as members of an underrepresented group on project reports.

(Dollars in Millions)

		FY 2022 Actuals[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request REVISED	Change Over FY 2023 Base Total[2] Amount	Change Over FY 2023 Base Total[2] Percent
Emphasis Programs[3]									
Computer Science for All (CSforAll)	61%	$14.79	$13.15	$1.83	-	$14.98	$14.98	-	-
CyberTraining	59%	11.42	12.34	-	-	12.34	12.34	-	-
Discovery Research PreK-12 (DRK-12)	68%	67.41	68.85	-	7.46	76.31	68.10	-0.75	-1.1%
EDU Core Research	72%	58.14	59.60	-	-	59.60	71.84	12.24	20.5%
Faculty Early Career Development Program (CAREER)	55%	220.55	234.24	-	-	234.24	207.80	-26.44	-11.3%
Graduate Research Fellowship Program (GRFP)	68%	196.34	155.71	62.28	-	217.99	257.48	39.48	18.1%
H-1B: Innovative Tech Experiences for Students & Teachers (ITEST)	72%	[25.15]	[34.79]	-	-	[34.79]	[35.94]	[-6.08]	[17.5%]
Improving Undergraduate STEM Education (IUSE)	75%	71.97	77.05	-	24.01	101.07	80.91	3.85	5.0%
International Research Experiences for Students (IRES)	58%	4.43	7.02	-	-	7.02	7.02	-	-
Resch Experiences for Teachers (RET) Sites in BIO, CISE, ENG	72%	9.21	5.82	-	-	5.82	9.50	3.68	63.2%
Resch Experiences for Undergrads (REU) - Sites and Supplements	63%	50.43	50.00	-	-	50.00	53.07	3.07	6.1%
Robert Noyce Teacher Scholarship Program (NOYCE)	60%	39.99	40.58	-	0.60	41.18	41.18	0.60	1.5%
Subtotal, Emphasis Programs		**$744.68**	**$724.37**	**$64.12**	**$32.07**	**$820.56**	**$824.21**	**$35.72**	**4.5%**

[1] FY 2022 Actual levels do not include funds provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[3] Totals exclude H-1B Visa funded programs (S-STEM and ITEST).

Geographic Diversity Programs

Geographic Diversity Programs, EPSCoR, has geographic diversity as an explicit goal of the program and is included at 100 percent of its funding.

(Dollars in Millions)

				Disaster Relief Supplemental				Change Over FY 2023 Base Total[2]	
		FY 2022 Actuals[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
Geographic Diversity Programs[3]									
EPSCoR	RRA	$215.06	$205.00	$50.00	-	$255.00	$280.68	$25.68	10.1%
Subtotal, Geographic Diversity Programs		**$215.06**	**$205.00**	**$50.00**	-	**$255.00**	**$280.68**	**$25.68**	**10.1%**

[1] FY 2022 Actual levels do not include funds provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[3] Totals exclude H-1B Visa funded programs (S-STEM and ITEST).

NATIONAL SCIENCE FOUNDATION
DIRECTORATE FOR STEM EDUCATION FUNDING BY DIVISION AND PROGRAM
FY 2024 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	FY 2022 Actuals	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request REVISED	Change over FY 2023 Base Total[1] Amount	Change over FY 2023 Base Total[1] Percent
Division of Equity for Excellence in STEM (EES)								
ADVANCE	$18.50	$19.00	-	$2.00	$21.00	$22.33	$3.33	17.5%
Alliances for Graduate Education and the Professoriate (AGEP)	8.50	9.50	-	3.00	12.50	15.50	6.00	63.2%
Centers for Research Excellence in Science and Technology (CREST)	26.01	29.00	-	3.00	32.00	41.00	12.00	41.4%
Eddie Bernice Johnson INCLUDES Initiative (INCLUDES Initiave)	23.01	30.00	-	5.00	35.00	50.50	20.50	68.3%
EDU Core Rsrch (ECR): Broadening Participation and Instit. Capacity in STEM	15.60	17.61	-	-	17.61	16.74	-0.87	-4.9%
Excellence Awards in Science and Engineering (EASE)	4.11	7.40	-	-	7.40	8.00	0.60	8.1%
Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)	38.01	43.00	-	3.00	46.00	48.50	5.50	12.8%
IUSE: Hispanic Serving Institutions (HSI) Program	24.26	26.75	-	1.00	27.75	30.25	3.50	13.1%
Louis Stokes Alliances for Minority Participation (LSAMP)	51.52	55.50	-	-	55.50	70.50	15.00	27.0%
Tribal Colleges and Universities Program (TCUP)	17.50	20.00	-	6.00	26.00	23.00	3.00	15.0%
EES Subtotal	**$227.03**	**$257.76**	**-**	**$23.00**	**$280.76**	**$326.32**	**$68.56**	**26.6%**
Division of Graduate Education (DGE)								
Cybercorps®: Scholarship for Service (SFS)	63.00	74.00	-	11.50	85.50	74.00	-	-
EDU Core Research (ECR): STEM Professional Workforce Preparation	19.11	19.12	-	-	19.12	20.86	1.74	9.1%
Graduate Research Fellowship Program (GRFP)	290.01	230.00	92.00	-	322.00	380.32	58.32	18.1%
NSF Research Traineeship (NRT)	60.00	60.00	-	28.50	88.50	62.50	2.50	4.2%
STEM Education Postdoctoral Research Fellowships	-	10.00	-	-	10.00	10.50	0.50	5.0%
Virtual Hubs to Support Key Transitions in Professional Growth	-	-	-	-	-	15.00	15.00	N/A
DGE Subtotal	**$432.11**	**$393.12**	**$92.00**	**$40.00**	**$525.12**	**$563.18**	**$78.06**	**16.1%**
Division of Research on Learning in Formal & Informal Settings (DRL)								
Advancing Informal STEM Learning (AISL)	$65.50	$70.00	-	$16.00	86.00	$80.00	10.00	14.3%
Artificial Intelligence Research Institutes, National	7.61	12.09	-	-	12.09	12.09	-	-
Computer Science for All (CSforAll)	10.04	10.00	-	-	10.00	10.00	-	-
Discovery Research PreK-12 (DRK-12)	98.50	100.60	-	10.90	111.50	99.50	-1.10	-1.1%
EDU Core Research (ECR): STEM Learning	30.32	30.33	-	-	30.33	38.74	8.41	27.7%
Research on Innovative Technologies for Enhanced Learning	-	-	-	-	-	15.00	15.00	N/A
DRL Subtotal	**$211.98**	**$223.02**	**-**	**$26.90**	**$249.92**	**$255.33**	**$32.31**	**14.5%**
Division of Undergraduate Education (DUE)								
Advanced Technological Education (ATE)	75.00	76.00	-	1.00	77.00	75.00	-1.00	-1.3%
EDU Core Research (ECR): STEM Learning Environments	15.85	15.85	-	-	15.85	23.60	7.75	48.9%
Improving Undergraduate STEM Education (IUSE)	93.50	93.50	-	32.10	125.60	93.50	-	-
IUSE: Hispanic Serving Institutions (HSI) Program	24.25	26.75	-	1.00	27.75	30.25	3.50	13.1%
Robert Noyce Teacher Scholarship Program (Noyce)	67.00	68.00	-	1.00	69.00	69.00	1.00	1.5%
STEM Teacher Corps	-	-	-	-	-	60.00	60.00	N/A
DUE Subtotal	**$275.60**	**$280.10**	**-**	**$35.10**	**$315.20**	**$351.35**	**$71.25**	**25.4%**
Total, EDU	**$1,146.72**	**$1,154.00**	**$92.00**	**$125.00**	**$1,371.00**	**$1,496.18**	**$250.18**	**20.1%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental appropriation base.

NATIONAL SCIENCE FOUNDATION
CoSTEM INVENTORY AND POSTDOCTORAL FELLOWSHIP PROGRAMS
BY LEVEL OF EDUCATION
FY 2024 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

		FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental: Base	Disaster Relief Supplemental: CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2]: Amount	Change over FY 2023 Base Total[2]: Percent
Minority-Serving Institutions		**$104.02**	**$116.50**	**-**	**$11.00**	**$127.50**	**$132.00**	**$15.50**	**13.3%**
UG	IUSE: Hispanic Serving Institutions Program (HSI) Program	48.50	53.50	-	2.00	55.50	60.50	7.00	13.1%
UG	Historically Black Colleges & Univ. Undergraduate Program (HBCU-UP)	38.01	43.00	-	3.00	46.00	48.50	5.50	12.8%
UG	Tribal Colleges and Universities Program (TCUP)	17.50	20.00	-	6.00	26.00	23.00	3.00	15.0%
Fellowships and Scholarships		**$723.70**	**$576.41**	**$92.00**	**$41.00**	**$709.41**	**$742.95**	**74.54**	**11.2%**
UG	NSF Scholarships in STEM (S-STEM) (H-1B)	243.70	144.41	-	-	144.41	149.13	4.72	3.3%
UG	Robert Noyce Scholarship (Noyce) Program	67.00	68.00	-	1.00	69.00	77.00	9.00	13.2%
G	CyberCorps®: Scholarship for Service (SFS)	63.00	74.00	-	11.50	85.50	74.00	-	-
G	Graduate Research Fellowship Program (GRFP)	290.01	230.00	92.00	-	322.00	380.32	58.32	18.1%
G	NSF Research Traineeship (NRT)	60.00	60.00	-	28.50	88.50	62.50	2.50	4.2%
Other Grant Programs		**$719.45**	**$759.53**	**$3.00**	**$68.00**	**$830.53**	**$862.40**	**99.87**	**13.1%**
K-12	Computer Science for All (CSforAll)	24.19	21.50	3.00	-	24.50	24.50	-	-
K-12	Discovery Research PreK-12 (DRK-12)	98.50	100.60	-	10.90	111.50	99.50	-1.10	-1.1%
K-12	Innovative Tech. Experiences for Teachers and Students (ITEST) (H-1B)	34.79	48.13	-	-	48.13	49.71	1.58	3.3%
UG	Advanced Technological Education (ATE)	75.00	76.00	-	1.00	77.00	75.00	-1.00	-1.3%
UG	Emerging Frontiers in Res. & Innovation (EFRI) Res. Experience & Mentoring	1.00	1.00	-	-	1.00	1.00	-	-
UG	Harnessing the Data Revolution (HDR): Data Science Corps (DSC)	3.38	3.00	-	-	3.00	-	-3.00	-100.0%
UG	Improving Undergraduate STEM Ed. (IUSE)	96.20	103.00	-	32.10	135.10	108.15	5.15	5.0%
UG	International Research Experiences for Students (IRES)	7.57	12.00	-	-	12.00	12.00	-	-
UG	Louis Stokes Alliances for Minority Participation (LSAMP)	51.52	55.50	-	-	55.50	70.50	15.00	27.0%
UG	Research Experiences for Undergraduates (REU) - Sites and Supplements	80.58	79.90	-	-	79.90	84.80	4.90	6.1%
UG	Research Experiences for Teachers (RET) in BIO, CISE, & ENG	12.80	8.09	-	-	8.09	13.20	5.11	63.2%
G	Alliances for Graduate Education and the Professoriate (AGEP)	8.50	9.50	-	3.00	12.50	15.50	6.00	63.2%
G	Research and Mentoring for Postbaccalaureates in Biological Sciences (RaMP)	32.47	30.00	-	-	30.00	49.10	19.10	63.7%
G	CyberTraining	19.44	21.00	-	-	21.00	21.00	-	-
O&I	Advancing Informal STEM Learning (AISL)	65.50	70.00	-	16.00	86.00	80.00	10.00	14.3%
O&I	EDU Core Research (ECR)[1]	80.89	82.91	-	-	82.91	99.94	17.03	20.5%
O&I	Excellence Awards in Science and Engineering (EASE)	4.11	7.40	-	-	7.40	8.00	0.60	8.1%
O&I	Eddie Bernice Johnson INCLUDES Initiative (INCLUDES Initiative)	23.01	30.00	-	5.00	35.00	50.50	20.50	68.3%
Subtotal, CoSTEM Inventory		**$1,547.17**	**$1,452.44**	**$95.00**	**$120.00**	**$1,667.44**	**$1,737.35**	**$189.91**	**12.3%**
G	**NSF Postdoctoral Programs**	**$46.87**	**$64.16**	**$7.00**	**$10.00**	**$81.16**	**$114.94**	**$43.78**	**61.5%**
	Astronomy and Astrophysics Postdoctoral Fellowships	1.57	2.40	-	-	2.40	2.40	-	-
	Engineering Postoctoral Fellowships[1]	[4.84]	3.00	-	-	3.00	3.00	-	-
	Entreprenural Fellowships	2.24	-	-	10.00	10.00	10.00	10.00	N/A
	Geosciences Postdoctoral Fellowships	14.84	10.90	-	-	10.90	16.14	5.24	48.1%
	Mathematical Sciences Postdoctoral Research Fellowships	6.40	4.36	4.00	-	8.36	9.00	0.64	7.7%
	MPS ASCEND Postdoctoral Research Fellowships	0.72	10.00	-	-	10.00	30.00	20.00	200.0%
	Postdoctoral Research Fellowships in Biology (PRFB)	18.04	20.50	-	-	20.50	24.90	4.40	21.5%
	SPRF-Broadening Participation	1.49	1.50	1.50	-	3.00	6.00	3.00	100.0%
	SPRF-Fundamental Research	1.55	1.50	1.50	-	3.00	3.00	-	-
	STEM Ed. Postdoctoral Research Fellowships[1]	[8.00]	10.00	-	-	10.00	10.50	0.50	5.0%
K-12 STEM Education Programs (K-12) Subtotal		**$157.48**	**$170.23**	**$3.00**	**$10.90**	**$184.13**	**$173.71**	**$0.48**	**0.3%**
Undergraduate STEM Education Programs (UG) Subtotal		**$742.76**	**$667.40**	**-**	**$45.10**	**$712.50**	**$722.78**	**$55.38**	**8.3%**
Graduate and Professional STEM Education Programs (G) Subtotal		**$520.28**	**$488.66**	**$99.00**	**$53.00**	**$640.66**	**$717.36**	**$129.70**	**22.1%**
Outreach and Informal STEM Education Programs (O&I) Subtotal		**$173.52**	**$190.31**	**-**	**$21.00**	**$211.31**	**$238.44**	**$48.13**	**25.3%**
Total, NSF STEM Education		**$1,594.03**	**$1,516.60**	**$102.00**	**$130.00**	**$1,748.60**	**$1,852.29**	**$233.69**	**14.4%**

[1] Launched in FY 2022 with American Rescue Plan Supplemental Appropriation Funds. FY 2022 funding shown for comparision purposes only.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental appropriation base.

NATIONAL SCIENCE FOUNDATION
RESEARCH INFRASTRUCTURE FUNDING, BY ACCOUNT AND ACTIVITY
FY 2024 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	FY 2022 Actual	FY 2022 Actual RI Funding	FY 2023 Estimate Base[1]	FY 2023 Estimate RI Funding	Disaster Relief Supplemental RI Base	Disaster Relief Supplemental RI Damage Mitigation	FY 2023 Estimate RI Total	FY 2024 Request REVISED	FY 2024 RI Funding	Change over FY 2023 RI Base Total[1] Amount	Change over FY 2023 RI Base Total[1] Percent
BIO	$831.62	$137.26	$856.98	$134.40	-	-	$134.40	$972.41	$133.79	-$0.61	-0.5%
CISE	1,014.72	177.51	1,050.57	161.10	30.00	-	191.10	1,172.14	220.89	29.79	15.6%
ENG	774.53	27.28	808.80	24.83	1.00	-	25.83	970.00	30.43	4.60	17.8%
GEO	1,035.72	438.85	1,068.15	424.27	24.32	-	448.59	1,236.38	495.68	47.09	10.5%
GEO: OPP	544.68	430.19	545.16	425.63	-	-	425.63	565.60	454.85	29.22	6.9%
MPS	1,615.26	419.52	1,683.34	363.36	60.90	2.50	426.76	1,835.79	502.95	78.69	18.5%
SBE	285.86	82.63	313.20	65.68	22.38	-	88.06	360.60	99.01	10.95	12.4%
TIP	413.09	0.10	670.00	-	-	-	-	1,185.63	-	-	N/A
OISE	54.23	0.10	69.32	0.10		-	0.10	71.21	0.10	-	-
IA	393.30	121.24	547.03	103.03	39.68	-	142.71	646.37	145.95	3.24	2.3%
USARC	1.66	-	1.75	-	-	-	-	1.77	-	-	N/A
R&RA	$6,964.66	$1,834.68	$7,614.30	$1,702.40	$178.28	$2.50	$1,883.18	$9,017.90	$2,083.65	$202.97	10.8%
EDU	$1,146.72	-	$1,246.00	-	-	-	-	$1,496.18	-	-	N/A
MREFC	$120.60	$119.95	$187.23	$186.23	-	-	$186.23	$304.67	$303.67	$117.44	63.1%
AOAM	$420.21	-	$463.00	-	-	-	-	$503.87	-	-	N/A
OIG	$18.89	-	$23.39	-	-	-	-	$26.81	-	-	N/A
NSB	$4.52	-	$5.09	-	-	-	-	$5.25	-	-	N/A
Total, NSF	**$8,675.61**	**$1,954.63**	**$9,539.01**	**$1,888.63**	**$178.28**	**$2.50**	**$2,069.41**	**$11,354.68**	**$2,387.32**	**$320.41**	**15.5%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

NATIONAL SCIENCE FOUNDATION

RESEARCH INFRASTRUCTURE SUMMARY

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Change over FY 2023 Base Total[1] Percent
Operations and Maintenance of Major Facilities[2]	**$985.95**	**$958.51**	**$44.23**	**$2.50**	**$1,005.24**	**$1,069.80**	**$67.06**	**6.7%**
Major Research Facilities Construction Investments	**$94.22**	**$122.41**	**-**	**-**	**$122.41**	**$213.72**	**$91.31**	**74.6%**
Construction, Acquisition, and Commissioning (MREFC)[3]	83.28	109.98	-	-	109.98	198.61	88.63	80.6%
Design Stage Activities[4]	10.94	12.43	-	-	12.43	15.11	2.68	21.6%
Mid-scale Research Infrastructure[5]	**$149.72**	**$144.97**	**$23.76**	**-**	**$168.73**	**$238.96**	**$70.23**	**41.6%**
MREFC Mid-scale Research Infrastructure (MREFC Account)	36.67	76.25	-	-	76.25	105.06	28.81	37.8%
NSF-wide Mid-scale Research Infrastructure (R&RA)	40.00	40.00	15.00	-	55.00	50.00	-5.00	-9.1%
Directorate Midscale Research Infrastructure Programs	73.05	28.72	8.76	-	37.48	83.90	46.42	123.9%
Major Research Instrumentation (MRI)	**$78.21**	**$63.75**	**$20.00**	**-**	**$83.75**	**$92.75**	**$9.00**	**10.7%**
Polar Logistical and Infrastructure Support[6]	**$153.52**	**$177.20**	**-**	**-**	**$177.20**	**$186.64**	**$9.44**	**5.3%**
CISE Netwrking & Computatnl Resrces Infrastrctre & Srvces (NCRIS)[7]	**$131.05**	**$129.80**	**$22.00**	**-**	**$151.80**	**$171.80**	**$20.00**	**13.2%**
Research Resources[8]	**$255.24**	**$198.19**	**$39.60**	**-**	**$237.79**	**$272.87**	**$35.08**	**14.8%**
Other Research Infrastructure	**$108.45**	**$95.52**	**$28.69**	-	**$124.21**	**$143.39**	**$19.18**	**15.4%**
Subtotal, Research Infrastructure Support	**$1,956.36**	**$1,890.35**	**$178.28**	**$2.50**	**$2,071.13**	**$2,389.93**	**$321.30**	**15.5%**
Research Infrastructure Stewardship Offset	-1.74	-1.72	-	-	-1.72	-2.61	-0.89	51.7%
RESEARCH INFRASTRUCTURE TOTAL	**$1,954.62**	**$1,888.63**	**$178.28**	**$2.50**	**$2,069.41**	**$2,387.32**	**$320.41**	**15.5%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[2] For facility level detail on operations and maintenance, see the Major Facilities Overview within the NSF-wide Investments chapter.

[3] Construction, Acquisition, and Commissioning are for implementation support provided through the MREFC account. MREFC funding is included for the Antarctic Infrastructure Recapitalization program, Vera C. Rubin Observatory, the High Luminosity-Large Hadron Collider Upgrade, Leadership-Class Computing Facility, Regional Class Research Vessels, and Mid-scale Research Infrastructure (shown on the MREFC Mid-scale RI line below). For more information, refer to the NSF-Wide investment/Research Infrastructure chapter.

[4] Design Stage Activities include support for potential next generation multi-user facilities. This line reflects $3.50 million in FY 2022 for the Leadership Class Computing Facility and $7.44 million, $12.43 million, and $15.11 million in FY 2022, FY 2023, and FY 2024 , respectively for the Antarctic Research Vessel (ARV)

[5] NSF-wide Mid-scale Research Infrastructure is provided through both the R&RA account (total project cost is less than $20.0 million) and the MREFC account (total project cost is greater than $20.0 million).

[6] Polar Logistical and Infrastructure Support includes funding for Arctic Logistics; U.S. Antarctic Logistical Support Activities (USALS); and Polar Environment, Health, and Safety (PEHS).

[7] FY 2022 funding for Networking and Computational Resources Infrastructure and Services (NCRIS) excludes support for the potential Leadership Class Computing Facility, which is captured under Design Stage Activities above.

[8] Funding for Research Resources includes support for the operation and maintenance of minor facilities, infrastructure and instrumentation, field stations, museum collections, etc.

NSF AUTHORIZATIONS AND OTHER REPORTS

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

Total NSF Funding

NATIONAL SCIENCE FOUNDATION CURRENT AUTHORIZATIONS

(Dollars in Millions)

LEGISLATION	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Authorization Levels FY 2022	FY 2023	FY 2024
National Science Foundation Act of 1950, P.L. 81-507[1]				*within limits of funds made available for this purpose within the limits of available appropriations to make such expenditures as may be necessary within the limit of appropriated funds utilize appropriations available*		
CHIPS and Science Act, P.L. 117-167 - see table below						
SBIR and STTR reauthorized through 2025 at current levels under the SBIR and STTR Extension act of 2022, P.L. 117-183						
Small Business Innovation Research (SBIR) Program[2]	**$202.41**	**$229.14**	**$262.84**	3.25% of research funds in 2022, 2023, and 2024		
Small Business Technology Transfer (STTR) Program[2]	**$28.48**	**$32.20**	**$35.84**	0.45% of research funds in 2022, 2023, and 2024		
National Earthquake Hazards Reduction Program Reauthorization Act of 2018, P.L. 115-307	**$52.00**	**$52.00**	**$54.00**	*$54.00*	*$54.00*	*$54.00*
Amends the Earthquake Hazards Reduction Act of 1977 to expand activities under the National Earthquake Hazards Reduction Program to include: (1) gathering information on community resilience (i.e., the ability of a community to prepare for, recover from, and adapt to earthquakes); (2) publishing a systematic set of maps of active faults and folds, liquefaction susceptibility, susceptibility for earthquake-induced landslides, and other seismically induced hazards; and (3) continuing the development of the Advanced National Seismic System, including earthquake early warning capabilities. *With respect to earthquake hazard reduction activities, the bill revises or expands the duties of: (1) the Interagency Coordinating Committee on Earthquake Hazards Reduction, (2) the National Institute of Standards and Technology (NIST), (3) the Federal Emergency Management Agency (FEMA), (4) the U.S. Geological Survey (USGS), and (5) the National Science Foundation.[3]*						
National Quantum Initiative Act, P.L. 115-368				*(Does not authorize appropriations)*		
Authorizes the National Science Foundation to carry out a basic research and education program on quantum information science and engineering, and award grants for the establishment of at least 2 but not more than 5 Multidisciplinary Centers for Quantum Research and Education up to $10 million each for each of fiscal years 2019 through 2023.	*	*	*			

NATIONAL SCIENCE FOUNDATION CURRENT AUTHORIZATIONS

(Dollars in Millions)

LEGISLATION	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Authorization Levels FY 2022	FY 2023	FY 2024
National Defense Authorization Act for Fiscal Year 2021, P.L. 116-283						
Sec 5401(f) Establishes the National Science Foundation Pilot Program of Grants for Research in Rapidly Evolving, High Priority Topics to assess the feasibility and advisability of awarding grants for the conduct of research in rapidly evolving, high priority topics using funding mechanisms that require brief project descriptions and internal merit review, and that may include accelerated external review. [4]	*	*	*	*$868.00*	*$911.40*	*$956.97*
H.R. 8810 - National Landslide Preparedness Act, P.L. 116-323				*NA*	*$11.00*	*$11.00*
Provide grants, on a competitive basis, to State, territorial, local, and Tribal governments to research, map, assess, and collect data on landslide hazards within the jurisdictions of those governmentsFor each of fiscal years 2021 through 2024 there is authorized to be appropriated to the National Science Foundation, $11,000,000 to carry out this section.	*	*	*			
H.R. 4704 - Advancing Research to Prevent Suicide Act, P.L. 116-339				*(Does not authorize appropriations)*		
Directs NSF to award competitive, merit-reviewed grants to institutions of higher education (or their consortia) to support multidisciplinary, fundamental research with potential relevance to suicide, including potential relevance to prevention and treatment. *In awarding such grants, the NSF shall encourage applications submitted by early career researchers, including doctoral students and postdoctoral researchers, to promote the researchers' development.*						
S. 2904 Identifying Outputs of Generative Adversarial Networks (IOGAN) Act, P.L. 116-258				*(Does not authorize appropriations)*		
Sec. 3 Directs National Science Foundation, in consultation with other relevant Federal agencies, shall support merit reviewed and competitively awarded research on manipulated or synthesized content and information authenticity,						

NATIONAL SCIENCE FOUNDATION CURRENT AUTHORIZATIONS

(Dollars in Millions)

LEGISLATION	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Authorization Levels FY 2022	FY 2023	FY 2024
H.R. 3153 - Expanding Findings for Federal Opioid Research and Treatment Act, P.L. 116-335				*(Does not authorize appropriations)*		
Sec. 2 Directs National Science Foundation, in collaboration withNational Institutes of Health shall support merit-reviewed and competitively awarded research on the science of opioid addiction.						
S. 153 - Supporting Veterans in STEM Careers Act, P.L. 116-115				*(Does not authorize appropriations)*		
Sec. 3 Directs National Science Foundation through the research and education activities of the Foundation, encourage veterans to study and pursue careers in STEM and computer science, in coordination with other Federal agencies that serve veterans.						

* NSF only reports actual amounts in the Authorizations Table.

[1] Organic legislation establishing NSF.

[2] SBIR and STTR are reauthorized through September 30, 2025.

[3] Authorizes $54.0 million for the National Earthquake Hazards Reduction Program at NSF for each of fiscal years FY 2019 through FY 2023.

[4] Authorizes appropriation of funds for the Pilot Program of Grants for Research in Rapidly Evolving, High Priority Topics. Outyear funding is $1,004,820,000 for fiscal year 2024; and $1,055,060,000 for fiscal year 2025.

CHIPS Act Funding Levels
Sec. 10303 Authorization of Appropriations

	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Mid-scale RI-1	$55.00	$60.00	$70.00	$75.00	$80.00
TIP Directorate	1,500.00	3,350.00	3,550.00	3,800.00	4,100.00
Unspecified Funding	7,495.00	8,640.00	9,230.00	9,925.00	10,520.00
Research & Related Activities	**$9,050.00**	**$12,050.00**	**$12,850.00**	**$13,800.00**	**$14,700.00**
NOYCE	73.70	80.40	87.10	93.80	100.50
NSF Research Traineeship (NRT)	59.50	64.91	70.32	75.73	81.14
GRFP	416.30	454.14	491.99	529.83	567.68
Cybercorps SFS	70.00	72.00	78.00	84.00	90.00
Fellowships, traineeships, per section 10393	350.00	800.00	900.00	950.00	1,000.00
STEM Teacher Corps Pilot (pg. 393)	60.00	60.00	60.00	60.00	60.00
Sec. 5 Auth. of Approps. (pg. 410)	150.00	150.00	150.00	150.00	150.00
Unspecified Funding	770.50	818.55	862.59	906.64	950.68
STEM Education	**$1,950.00**	**$2,500.00**	**$2,700.00**	**$2,850.00**	**$3,000.00**
Mid-scale RI-2	76.25	80.00	85.00	90.00	100.00
MREFC	**$249.00**	**$355.00**	**$370.00**	**$372.00**	**$375.00**
AOAM	**$620.00**	**$710.00**	**$750.00**	**$770.00**	**$800.00**
OIG	**$23.39**	**$26.61**	**$31.11**	**$34.61**	**$38.11**
NSB	**$5.09**	**$5.32**	**$5.56**	**$5.81**	**$6.07**
Total, NSF	**$11,897.48**	**$15,646.93**	**$16,706.67**	**$17,832.42**	**$18,919.18**

NATIONAL SCIENCE FOUNDATION (NSF)
COMPUTER SCIENCE EDUCATION RESEARCH CONGRESSIONAL REPORT
IN COMPLIANCE WITH PUBLIC LAW 114-329:
AMERICAN INNOVATION AND COMPETITIVENESS ACT, SEC. 310 (E)

Summary

The American Innovation and Competitiveness Act, 2017, Public Law 114-329, requires the National Science Foundation (NSF) to undertake specific activities regarding computer science education research (Sec. 310):

"(b) GRANT PROGRAM. —

(1) IN GENERAL. — The Director of the Foundation shall award grants to eligible entities to research computer science education and computational thinking.

(2) RESEARCH. — The research described in paragraph (1) may include the development or adaptation, piloting or full implementation, and testing of —

A. models of preservice preparation for teachers who will teach computer science and computational thinking;

B. scalable and sustainable models of professional development and ongoing support for the teachers described in subparagraph (A);

C. tools and models for teaching and learning aimed at supporting student success and inclusion in computing within and across diverse populations, particularly poor, rural, and tribal populations and other populations that have been historically underrepresented in computer science and STEM fields; and

D. high-quality learning opportunities for teaching computer science and, especially in poor, rural, or tribal schools at the elementary school and middle school levels, for integrating computational thinking into STEM teaching and learning.

(c) COLLABORATIONS. — In carrying out the grants established in subsection (b), eligible entities may collaborate and partner with local or remote schools to support the integration of computing and computational thinking within pre-kindergarten through grade 12 STEM curricula and instruction.

(d) METRICS. — The Director of the Foundation shall develop metrics to measure the success of the grant program funded under this section in achieving program goals.

(e) REPORT. — The Director of the Foundation shall report, in the annual budget submission to Congress, on the success of the program as measured by the metrics in subsection (d).

(f) DEFINITION OF ELIGIBLE ENTITY. — In this section, the term "eligible entity" means an institution of higher education or a non-profit research organization."

Background

NSF's Computer Science for All (CSforAll) activities address the national need to build computer science education opportunities and teacher preparation at the preK-12 level, as part of building the U.S. economy. Projects are expected to address equity issues in computer science education, including the participation of girls and women and other groups historically under-represented in computing, including some racial or ethnic identities, students with disabilities, students from economically disadvantaged backgrounds, and more.

NSF launched Computer Science for All: Researcher Practitioner Partnerships (CS for All: RPP) under the (STEM+C) program in 2017 with solicitation NSF 17-525[1]. In 2018, NSF issued an updated solicitation (NSF 18-537)[2] making CSforAll a stand-alone program. In 2020, NSF issued an updated solicitation Computer Science for All (CSforAll: Research and RPPs), NSF 20-539[3]. As the new name suggests, this updated solicitation added a focus on research to serve the goals of the program. Specifically, a new research strand was added to support projects designed to contribute new knowledge to the educational field about the teaching and learning of introductory computer science concepts.

The CS for All: Research and RPPs program synopsis in the program solicitation states that:

> This program aims to provide all U.S. students with the opportunity to participate in computer science (CS) and computational thinking (CT) education in their schools at the preK-12 levels. With this solicitation, the National Science Foundation (NSF) focuses on both research and researcher-practitioner partnerships (RPPs) that foster the research and development needed to bring CS and CT to all schools. Specifically, this solicitation aims to provide (1) high school teachers with the preparation, professional development (PD) and ongoing support they need to teach rigorous computer science courses; (2) preK-8 teachers with the instructional materials and preparation they need to integrate CS and CT into their teaching; and (3) schools and districts with the resources needed to define and evaluate multi-grade pathways in CS and CT.

Metrics

Short-, mid-, and longer-term metrics for success are considered by the program as follows:

- Short-term metrics focus on ensuring that the program is making awards in the four areas outlined in the law and that the awards address the goal of broadening participation in computer science. One indicator of broadening participation is the diversity of the intended populations to be reached by the awards. CSforAll considers 'short-term' metrics to be those which are observable on an annual basis. To date, the program has only reported progress with respect to these short-term metrics.
- Mid-term metrics include the extent to which funded projects are achieving goals as measured by the progress reported in NSF's required annual and final project reports. CSforAll operationalizes 'mid-term' as progress that individual projects can reasonably be expected to achieve within three years of award.
- Longer-term (beyond five years) metrics will include an evaluation of the outcomes of the program, which are based on the program aims as described in the program solicitation and the well-aligned requirements of Public Law 114-329. Program staff will work with the Evaluation and Monitoring Group within NSF's Directorate for STEM Education and the Evaluation and Assessment Capability within NSF's Office of Integrative Activities to develop (1) a set of specific longer-term metrics and (2) a program evaluation plan for assessing the collective success of the CS for All: RPP projects using these longer-term metrics.

[1] www.nsf.gov/pubs/2017/nsf17525/nsf17525.htm
[2] www.nsf.gov/pubs/2018/nsf18537/nsf18537.htm
[3] www.nsf.gov/pubs/2020/nsf20539/nsf20539.htm

Report on the Success of the Program as Measured by the Short-Term Metrics

During FY 2022, the program funded 17 new projects comprised of 21 awards to proposals submitted pursuant to NSF 20-539. These awards have goals that cover the first three research topics listed in Sec. 310 of the Act as outlined below. Because some awards have goals that span more than one of the research topics addressed in (b)(2) A, B, and C, the number of projects sums to more than 17.

- 15 projects have research goals on preservice preparation and ongoing professional development for teachers that address subsection (b)(2) A and (b)(2) B
- 17 projects have research goals on tools and models for teaching and learning that address subsection (b)(2) C
- 3 projects have research goals that address multi-grade pathways to CT and CS

Examples of CSforAll-supported efforts to address the developments or adaptation, piloting or full implementation, and testing of models of preservice preparations for teachers who will teach computer science and computational thinking and/or scalable and sustainable models of professional development and ongoing support for these teachers, can be found at the CSforAll program website[4]. Taken as a group, these awards consider a range of opportunities to expand CS education and computational literacy. These include methods for sustainable scaling using school and district networks, and regionally-focused K-12 efforts. Projects also engage a broader cross-section of students in CS education through place-based strategies and lessons connected to local communities.

With respect to subsection (b)(2) D, all 17 new awards have explicit statements and plans to address at least one underrepresented or underserved group included in the project descriptions. The specific groups addressed by these 17 awards are detailed in the following table. Thus, because some awards serve more than one underrepresented group, the number of awards sums to more than 17. Additionally, the geographic spread of CSforAll awards can be viewed on NSF's website[5].

Underrepresented or Underserved Groups Served by Backbone Organizations

Category	Number of awards serving
Latino/a	10
Low Socio-Economic Status	10
African Americans	8
Women/Girls	6
English Language Learners	5
Persons with Disabilities	4
Native Americans	2
Native Hawaiians & Pacific Islander	-

[4] Computer Science for All (CSforAll: Research and RPPs) | Beta site for NSF - National Science Foundation; https://beta.nsf.gov/funding/opportunities/computer-science-all-csforall-research-and-rpps

[5] Computer Science For All Active Awards; www.nsf.gov/awards/award_visualization.jsp?org=NSF&pims_id=505359&ProgEleCode=005Y%2C134Y&from=fund#

Report on the Success of the Program as Measured by the Mid-Term Metrics

Mid-term metrics assess progress that individual projects can reasonably be expected to achieve within three years of award. Measurement of mid-term metrics is based on information contained in projects' annual reports. Since we are reporting on FY 2022, mid-term metrics are given for the 25 awards that NSF issued in FY 2019.

In their annual reports, awardees are requested to provide information about the progress of their individual projects:

- What are the major goals of the project?
- What was accomplished under these goals and objectives? What were the major activities, the specific objectives, significant results, and key outcomes?
- What opportunities for training and professional development has the project provided?
- Have the results been disseminated to communities of interest?
- What do you plan to do during the next reporting period to accomplish the goals?

Based on the responses of the awardees, program staff assessed that 100 percent of projects awarded in FY 2019 have been making satisfactory progress for each year of the project duration. "Satisfactory progress" refers to criteria such as whether the stated goals of the project are being met; whether the major activities are in line with those planned in the original grant proposal; whether the opportunities for training and professional development are in line with those promised; and whether dissemination is occurring as planned. Projects voluntarily included information about the number of teachers reached. For example, the 25 awarded projects from FY 2019 reported a total of approximately 922 teachers, and the aggregated information from individual projects suggested that CSforAll is successful in the mid-term.

Report on the Success of the Program as Measured by the Longer-Term Metrics

In FY 2023, program staff is consulting with colleagues in NSF's Evaluation and Assessment Capability and the Directorate for STEM Education to identify metrics for assessing outcomes of the program's support for (a) preparation and ongoing professional development for high school teachers who provide instruction in computer science, and (b) instructional materials and preparation for K-8 teachers who integrate computer science and/or computational thinking into their teaching. With this in mind, NSF will employ these metrics in periodic evaluations of long-term program outcomes. To date, only one cohort of awards (those made in FY 2017) have reached the 'longer-term' (beyond five years) benchmark. Further, to provide more robust information on typical outcomes at the five-year mark across cohorts, NSF will commission an independent third-party evaluation in FY 2024.

NATIONAL SCIENCE FOUNDATION (NSF)
ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCOR)
CONGRESSIONAL REPORT IN COMPLIANCE WITH PUBLIC LAW 114-329: AMERICAN INNOVATION AND COMPETITIVENESS ACT, SEC. 103 (D) (1-3)
FISCAL YEAR 2022

This report summarizes fiscal year (FY) 2022 NSF funding to institutions and entities in EPSCoR jurisdictions, as required by the American Innovation and Competitiveness Act Sec. 103(d)(1-3). Specifically, the report details:

(1) a description of the program strategy and objectives;
(2) a description of the awards made in the previous fiscal year including:
  (A) the total amount made available, by state, under EPSCoR;
  (B) the total amount of agency funding made available to all institutions and entities within each EPSCoR state;
  (C) the efforts and accomplishments to more fully integrate the EPSCoR states in major agency activities and initiatives;
  (D) the percentage of EPSCoR reviewers from EPSCoR states;
  (E) the number of programs or large collaborator awards involving a partnership of organizations and institutions from EPSCoR and non-EPSCoR states; and
(3) an analysis of the gains in academic research quality and competitiveness, and in science and technology human resource development, achieved by the program over the last 5 years.

EPSCoR Strategies and Objectives (Sec. 103(d)(1)).c

EPSCoR's strategies and objectives in FY 2022 remain the same as those described in the FY 2021 report. Specifically, the mission of EPSCoR is "to enhance research competitiveness of targeted jurisdictions (states, territories, commonwealths) by strengthening Science, Technology, Engineering and Mathematics (STEM) capacity and capability." EPSCoR's goals are:

- To catalyze the development of research capabilities and the creation of new knowledge that expands jurisdictions' contributions to scientific discovery, innovation, learning, and knowledge-based prosperity.
- To establish sustainable STEM education, training, and professional development pathways that advance jurisdiction-identified research areas, NSF focus areas, and workforce development.
- To broaden direct participation of diverse individuals, institutions, and organizations in the project's science and engineering research and education initiatives.
- To affect sustainable engagement of project participants and partners, the jurisdiction, the national research community, and the general public through data-sharing, communication, outreach, and dissemination.
- To impact research, education, and economic development beyond the project at academic, government, and private sector levels.

EPSCoR uses three investment strategies in pursuit of its goal to strengthen research capacity and competitiveness in eligible jurisdictions. These investment strategies are: (1) Research Infrastructure Improvement (RII) awards that support physical, human, and cyberinfrastructure development; (2) Co-Funding in partnership with NSF directorates and offices that support individual investigators and groups within EPSCoR jurisdictions; and (3) Outreach activities and workshops that bring EPSCoR

jurisdiction investigators together with program staff from across the Foundation to explore opportunities in emerging areas of science and engineering aligned with NSF strategic priorities and with jurisdictional science and technology goals.

EPSCoR's RII programs are instrumental in helping to build jurisdictional capability and capacity. RII Track-1 awards provide up to $4.0 million per year for up to five years. They are intended to improve the research competitiveness of jurisdictions by improving their academic research infrastructure in areas of science and engineering supported by NSF and critical to the particular jurisdiction's science and technology initiative or plan. RII Track-2 Focused EPSCoR Collaborations awards provide up to $1.0 million per year for up to four years as collaborative awards between two EPSCoR jurisdictions or up to $1.5 million per year for up to four years to a consortium of three or more EPSCoR jurisdictions. These awards build interjurisdictional collaborative teams of EPSCoR investigators in scientific focus areas consistent with NSF priorities. RII Track-4: EPSCoR Research Fellows provides opportunities for early career, non-tenured, and tenured assistant/associate professor faculty to further develop their individual research potential through extended collaborative visits to the nation's premier private, governmental, or academic research centers. Through these visits, the EPSCoR Research Fellows learn new techniques, benefit from access to unique equipment and facilities, and shift their research toward transformative new directions. The experience gained through the fellowship is intended to provide a foundation for research collaborations that span the recipient's entire career. These benefits to the Fellows are also expected to in turn enhance the research capacity of their institutions and jurisdictions.

EPSCoR often co-funds proposals submitted to other NSF programs if the applicant is located in an EPSCoR jurisdiction. The proposals selected for this funding have been merit reviewed and recommended for award but could not be funded without the combined support of EPSCoR and the co-funding directorates. Co-funding leverages EPSCoR investment and facilitates participation of EPSCoR scientists and engineers in NSF-wide programs and initiatives.

EPSCoR also funds workshops, conferences, and other community-based activities to explore opportunities in emerging areas of science and engineering, and to share best practices in strategic planning, diversity, communication, cyberinfrastructure, evaluation and other areas of importance to EPSCoR jurisdictions. In addition, EPSCoR supports outreach travel that enables NSF staff from all directorates and offices to work with the EPSCoR research community on NSF opportunities, priorities, programs, and policies. This travel better acquaints NSF staff with the science and engineering accomplishments, ongoing activities and new directions and opportunities in research and education in EPSCoR jurisdictions.

In FY 2022, EPSCoR completed a year-long visioning activity led by a subcommittee of the Committee on Equal Opportunities in Science and Engineering (CEOSE). The subcommittee's report, *Envisioning the Future of NSF EPSCoR*[1]*,* builds on extensive programmatic data as well as prolonged engagement with EPSCoR's external stakeholders to better understand the impacts of the program's investment strategies and identify new opportunities for increased success. This process provided an opportunity for NSF EPSCoR and its stakeholder community to deeply and collaboratively assess how the NSF program can work most effectively with its jurisdictional partners to achieve their shared goals in the context of the nation's changing STEM research landscape.

[1] CEOSE. 2022. Envisioning the Future of NSF EPSCoR. Alexandria, VA: National Science Foundation.

NSF Funding Made Available, by Jurisdiction, under EPSCoR (Sec. 103(d)(2)(A)).

In FY 2022, NSF EPSCoR invested a total of $231.74 million in support of programmatic activities. Funding consisted of $215.06 million in FY 2022 regular appropriations, and $16.68 million in supplemental appropriations provided through the American Rescue Plan of 2021 (P.L. 117-2). Within the FY 2022 total, $162.83 million (70.3 percent) was directed to 99 RII awards, $52.11 million (22.5 percent) to 191 co-funded awards, $16.69 million (7.2 percent) to American Rescue Plan programs (18 awards), and $110,000 (<0.1 percent) to outreach activities and one workshop. The table below details the investments from EPSCoR resources and EPSCoR investments in co-funding actions.

FY 2022 EPSCoR Funding by Jurisdiction

(Dollars in Millions)

EPSCoR Jurisdiction	RII Program	Outreach & Workshops	EPSCoR Co-funding	American Rescue Plan	EPSCoR Total
AK	$4.11	-	$0.39	-	$4.50
AL	8.84	-	3.30	3.16	15.30
AR	11.06	-	0.71	-	11.77
DE	2.51	-	3.50	1.09	7.10
GU	3.95	-	-	-	3.95
HI	4.90	-	2.80	1.40	9.10
IA	1.57	-	1.16	-	2.73
ID	5.49	-	10.98	-	16.47
KS	8.96	-	1.39	1.00	11.35
KY	7.47	-	2.34	0.99	10.80
LA	8.02	-	1.85	-	9.87
ME	14.91	-	1.36	0.98	17.25
MS	2.67	0.10	3.11	-	5.88
MT	5.19	-	3.44	-	8.63
ND	1.50	-	0.22	-	1.72
NE	10.68	-	1.98	1.00	13.66
NH	7.58	-	1.58	-	9.16
NM	5.77	-	1.16	-	6.93
NV	4.69	-	1.03	0.42	6.14
OK	9.53	-	2.54	2.14	14.21
PR	3.44	-	1.00	-	4.44
RI	1.17	-	1.55	-	2.72
SC	1.23	-	0.67	1.00	2.90
SD	10.71	-	1.55	2.00	14.26
VI	4.21	-	-	1.50	5.71
VT	1.92	-	1.00	-	2.92
WV	1.51	-	0.49	-	2.00
WY	4.19	-	0.15	-	4.34
Admin	5.05	0.01	0.86	0.01	5.93
Total	**$162.83**	**$0.11**	**$52.11**	**$16.69**	**$231.74**

Total NSF Funding Made Available in all EPSCoR Jurisdictions (Sec. 103 (d)(2)(B)).

In FY 2022, NSF invested a total of $1,116.01 million in support of EPSCoR jurisdictions. The table below details NSF investments in EPSCoR jurisdictions including research support funding, education and human resources, and major research equipment.

FY 2022 NSF Funding Made Available to All EPSCoR Jurisdictions
(Dollars in Millions)

EPSCoR Jurisdiction	NSF Funding
AK	$52.22
AL	79.29
AR	42.37
DE	46.36
GU	4.82
HI	48.78
IA	58.91
ID	42.17
KS	47.93
KY	41.60
LA	64.91
ME	37.97
MS	27.97
MT	42.73
ND	20.48
NE	55.81
NH	38.41
NM	54.54
NV	36.97
OK	51.65
PR	18.91
RI	45.09
SC	68.22
SD	28.45
VI	9.63
VT	13.45
WV	16.27
WY	20.10
Total	**$1,116.01**

Integration of EPSCoR Jurisdictions in Major Activities and Initiatives of the Foundation (Sec. 103 (d)(2)(C)).

All EPSCoR programmatic activities target integration and assimilation of EPSCoR jurisdictions into the research and education programs of the Foundation's disciplinary directorates. RII awards promote the coordination and integration of recipient jurisdictions into major NSF programmatic activities. Additionally, EPSCoR consults and engages NSF disciplinary program officers (POs) in merit review processes and post-award evaluations, such as site visits and reverse site visits (RSVs). Site visits and RSVs are intended to provide additional project oversight by allowing jurisdictions to report on the progress of their RII projects in relation to their stated goals and the programmatic terms and conditions. Disciplinary POs assist in the identification of reviewers for RII merit review panels, serve as site visit and RSV observers, and provide knowledge about the ongoing activities within the directorate that could be leveraged to sustain RII efforts after the performance period of the EPSCoR award.

National, regional, and jurisdictional meetings of the EPSCoR community facilitate grantee interactions with NSF leadership to learn about the Foundation's strategic priorities and funding opportunities. Participation by EPSCoR researchers and educators in the merit review process across all disciplinary domains of the Foundation, in Committees of Visitors (COV) activities, in external advisory (Federal Advisory Committee Act) committees, and in disciplinary workshops that shape new activities is also vital to this integration.

Outreach to EPSCoR jurisdictions by NSF staff promotes integration of the EPSCoR community into mainstream NSF programs, as does co-funding of awards with the disciplinary programs of the Foundation. There is also an effort to promote in-reach, whereby EPSCoR facilitates opportunities for researchers and educators from EPSCoR jurisdictions to meet with NSF staff. In these meetings, the EPSCoR participants are provided with information on NSF strategic priorities and funding opportunities.

In FY 2022, EPSCoR staff promoted engagement of the EPSCoR community in NSF and other national activities. Examples are:

- Hosted its 2022 EPSCoR Annual Principal Investigator (PI) Meeting virtually during the third week of May. The EPSCoR community and NSF POs shared effective practices in research, strategic planning, diversity, communication, evaluation, and other areas of importance to EPSCoR jurisdictions and NSF. In addition to presentations and breakout sessions, there were Track-specific roundtables that offered valuable insight to PIs. The agenda also included sessions for PIs to meet with POs from other federal EPSCoR programs and NSF directorates to discuss program-specific funding opportunities. Every EPSCoR jurisdiction was represented at this meeting, which had approximately 300 participants.
- Encouraged EPSCoR-supported faculty to participate in NSF committee and review panels across NSF (e.g., COVs, site visits, and merit review panels).
- Maintained investment in RII Track-2: Focused EPSCoR Collaborations (RII Track-2 FEC). In FY 2022, proposals were invited on the topic of "Advancing research toward Industries of the Future to ensure economic growth for EPSCoR jurisdictions," aligned with NSF's emerging industries initiative. Six awards were made in FY 2022, representing a total EPSCoR investment of $34.0 million over their four-year award duration.
- Continued RII Track-4: EPSCoR Research Fellows, with 32 awards made, representing a total

EPSCoR investment of $6.30 million over their two-year award duration.

- Continued Track-4 Fellows: Advancing Science and Technology (FAST), a collaboration with NASA-EPSCoR. Track-4: FAST allows for PIs from MSIs to further develop their individual research potential through extended collaborative visits to NASA research facilities located at NASA Centers throughout the United States. One of the 32 awards made for the FY 2022 RII Track-4 competition was made through the Track-4: FAST mechanism.
- Funded $10.50 million in support to the ~~RII~~ Bridging EPSCoR Communities (BEC) initiative, which was primarily funded by American Rescue Plan resources. The RII-BEC initiative seeks to enable institutions in EPSCoR jurisdictions to set up bridge programs to facilitate the transitions of groups affected by COVID (e.g., women, groups traditionally underrepresented in STEM, research trainees, and graduate fellows) from one stage of STEM training to the next, with particular focus on providing support for individuals from groups underrepresented in STEM and those transitioning from or to minority-serving institutions (MSIs) within EPSCoR jurisdictions.
- Invested $6.70 million in support of Campus Cyberinfrastructure (CC*) awards to EPSCoR jurisdictions through the American Rescue Plan funding. The CC* program invests in coordinated campus-level networking and cyberinfrastructure improvements, innovation, integration, and engineering for science applications and distributed research projects.
- Contributed $2.20 million in co-funding towards the MonArk Quantum Foundry, a collaboration between Montana State University and the University of Arkansas to accelerate the development of layered two-dimensional (2D) materials and devices for applications in quantum sensing, communication, and computing.
- Committed $3.10 million to fund 14 awards related to acquisition of major research instrumentation and equipment. These fundamental infrastructure-building awards will help to build STEM capacity in EPSCoR jurisdictions.
- Provided $13.90 million for 46 CAREER awards for early-career faculty in EPSCoR jurisdictions. The NSF CAREER program supports early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization.
- Convened two meetings with the EPSCoR Interagency Coordinating Committee (EICC) to share relevant program information and identify opportunities for maximizing jurisdictional impact. Representatives from the EICC also presented information on their programs at a panel session during the annual PI meeting for PIs interested in learning more about leveraging funding opportunities.
- NSF funded three Mid-scale Research Infrastructure Track 1 (Mid-scale RI-1) awards ($21.30 million) in EPSCoR jurisdictions, which leveraged $9.70 million in EPSCoR Co-funding resources. Mid-scale RI-1 supports the design and implementation of research infrastructure — including equipment, cyberinfrastructure, large-scale datasets and personnel — whose total project costs exceed NSF's Major Research Instrumentation program but are under $20.0 million.

EPSCoR Reviewers (Sec. 103(d)(2)(D)).

EPSCoR collects demographics of all reviewers who evaluate EPSCoR proposals. In FY 2022, 235 out of 306 reviewers self-identified their demographics. Of those 235 reviewers, 40.5 percent were female, 19.6 percent were from groups traditionally underrepresented in STEM, 0.7 percent were disabled, and 20.9 percent were from EPSCoR jurisdictions.

EPSCoR Collaborations and Partnerships (Sec. 103(d)(2)(E)).

All RII awards involve collaborations among scientists and engineers in EPSCoR jurisdictions. Though funding is awarded to a primary institution, there are always several subaward institutions involved in RII Track-1 and Track-2 awards. Subaward funding is not reflected in the tables provided earlier in this report but does help to enhance jurisdictional competitiveness. Data on research progress and outcomes are collected from subawards as well as the primary institution. In addition to subaward partnerships, RII awards require institutional collaborations, which are defined as collaborations among researchers at a RII awardee or sub-awardee and those at institutions not receiving any RII funds. These institutional collaborations and partnerships help to drive economic development and catalyze technology transfer within and across jurisdictions.

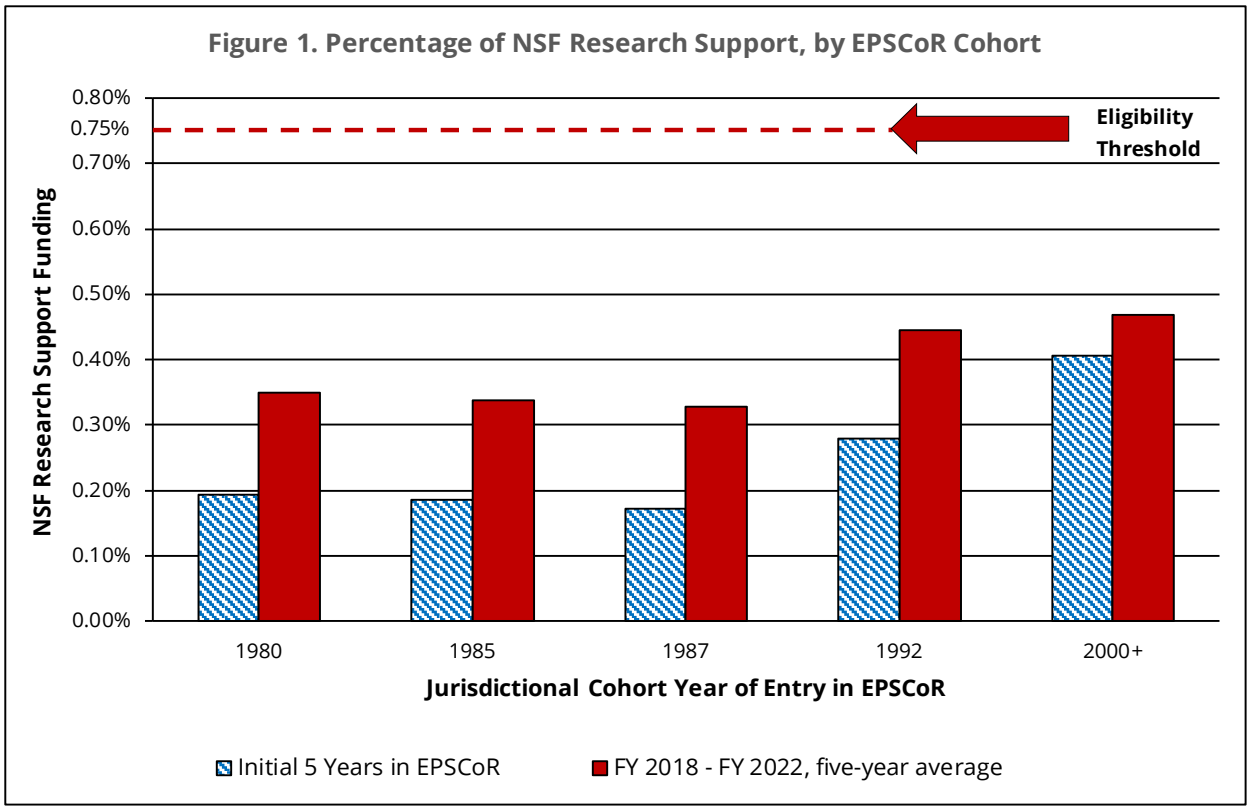
In FY 2022, RII Track-1 participants developed 490 institutional collaborations within EPSCoR jurisdictions; 599 institutional collaborations between EPSCoR jurisdictions and non-EPSCoR jurisdictions; and 150 collaborations between institutions in EPSCoR jurisdictions and in foreign countries. These collaborative efforts highlight the vast network of institutional involvement among EPSCoR jurisdictions and their partners in RII Track-1 projects. Of these 1,239 collaborations, 82 (6.6 percent) were with national laboratories and 137 (11.1 percent) were with industry partners.

Among the 191 awards co-funded by EPSCoR in FY 2022, 135 involved collaborative research between multiple institutions. Of those 135 collaborative awards, 106 (78.5 percent) were collaborations between investigators from institutions in EPSCoR and non-EPSCoR jurisdictions.

An analysis of the gains in academic research quality and competitiveness, and in science and technology human resource development, achieved by the program over the last 5 fiscal years (Sec. 103(d)(3)).

Eligibility to participate in NSF EPSCoR programmatic activities is based upon the jurisdictions' demonstrated ability to obtain NSF funding. Currently, a jurisdiction is eligible to participate in EPSCoR programs if its level of NSF funding is equal to or less than 0.75 percent of the total NSF budget over the most recent five-year period, excluding NSF funding to other federal agencies and EPSCoR RII and workshop/conference funding. Jurisdictions above 0.75 percent but less than 0.80 percent are allowed to remain EPSCoR-eligible for up to five years. Given EPSCoR's aim to stimulate research that is fully competitive in NSF's disciplinary and multidisciplinary research programs, increases in the ability to capture NSF research funds serve as a proxy for gains in research competitiveness.

Figure 1 (below) shows the average annual amount of NSF research funds given to each cohort for the initial five years (hatched bars) and the most recent five years (solid bars) of their participation in NSF EPSCoR. A cohort is defined as the group of states or jurisdictions that entered EPSCoR within a given fiscal year. For example, the 1980 cohort consists of the initial five states that qualified for EPSCoR at that time. For this summary, the 2000+ cohort consists of jurisdictions that entered EPSCoR in FY 2000 or later and are still EPSCoR-eligible for RII competitions. Former EPSCoR jurisdictions Missouri, Tennessee, and Utah are excluded because they were not EPSCoR-eligible in FY 2022.



Each cohort shows an increase in competitiveness over the periods of participation. For example, the 1980 cohort (Arkansas, Maine, Montana, South Carolina, West Virginia) shows an 80 percent increase in NSF research funding over the past 42 years of EPSCoR activity. The 1985 cohort (Alabama, Kentucky, Nevada, North Dakota, Oklahoma, Puerto Rico, Vermont, and Wyoming) demonstrates an 81 percent increase during its 37 years of participation in EPSCoR. The 1987 cohort (Idaho, Louisiana, Mississippi, and South Dakota) shows a 91 percent increase over the past 35 years, whereas the 1992 cohort (Kansas and Nebraska) has a 59 percent increase in competitiveness over its 30 years of EPSCoR involvement. Currently eligible jurisdictions participating in EPSCoR since FY 2000 entered into the program at a higher level of NSF research funding than the previous cohorts. For the 2000+ cohort (Alaska, Delaware, Guam, Hawaii, Iowa, New Hampshire, New Mexico, Rhode Island, and the Virgin Islands), there has been a small, yet demonstrable 15 percent increase in research funding.

Percentage of NSF Funding,
by Jurisdiction and EPSCoR Cohort

	Initial 5 Years in EPSCoR*	Most Recent 5 Year Period (FY 2018-2022)**	Percent Change Over Time
1980 Cohort	0.19%	0.35%	80%
Arkansas	0.10%	0.31%	223%
Maine	0.27%	0.27%	-1%
Montana	0.13%	0.42%	223%
South Carolina	0.41%	0.57%	41%
West Virginia	0.07%	0.18%	165%
1985 Cohort	0.19%	0.34%	81%
Alabama	0.33%	0.77%	133%
Kentucky	0.22%	0.40%	86%
Nevada	0.14%	0.35%	146%
North Dakota	0.06%	0.17%	174%
Oklahoma	0.30%	0.43%	44%
Puerto Rico	0.15%	0.22%	47%
Vermont	0.10%	0.13%	33%
Wyoming	0.20%	0.23%	17%
1987 Cohort	0.17%	0.33%	91%
Idaho	0.08%	0.32%	316%
Louisiana	0.36%	0.57%	58%
Mississippi	0.16%	0.27%	72%
South Dakota	0.09%	0.15%	65%
1992 Cohort	0.28%	0.45%	59%
Kansas	0.34%	0.46%	35%
Nebraska	0.22%	0.43%	97%
2000+ Cohort	0.41%	0.47%	15%
Alaska	0.55%	0.67%	21%
Delaware	0.41%	0.50%	22%
Guam	0.02%	0.01%	-50%
Hawaii	0.56%	0.62%	11%
Iowa***	N/A	0.69%	N/A
New Hampshire	0.44%	0.42%	-5%
New Mexico	0.58%	0.63%	9%
Rhode Island	0.70%	0.63%	-10%
Virgin Islands	-	0.04%	N/A

*Percentages based on eligibility guidelines at the time of entry into the EPSCoR program.

**Percentages based on current eligibility guidelines.

***Iowa reentered EPSCoR eligibility in FY 2019; data for the initial five years not available.

Additional EPSCoR Impacts – FY 2022

This section provides FY 2022 EPSCoR RII Tracks 1 and 2 science and technology outputs of academic research capacity, human resource development, and the demographics of participants. FY 2022 data is provided, as EPSCoR's data reporting infrastructure is being enhanced in FY 2023 to ensure greater consistency in jurisdictional reporting including for project outcomes and impacts. Therefore, beginning with the FY 2023 report, NSF will begin showing multi-year gains and impacts, which will eventually result in a five-year data presentation.

The following table demonstrates quantifiable outputs of NSF EPSCoR's RII Track-1 and Track-2 programs in FY 2022. This information clarifies the gains in academic research capacity and competitiveness, as defined by publications, leveraged grants, and patents, all strong indicators of economic development. The number and valuation of grants awarded encompass all federal, private industry, and private foundation awards across the U.S. for all active projects. These leveraged grants help to build on EPSCoR-funded research and drive academic capacity and capability across EPSCoR jurisdictions.

FY 2022 RII Track-1 and Track-2 Aggregate of EPSCoR Outputs

	Track-1	Track-2	Total
Number of Active Awards	25	43	68
Publications	765	190	955
Grants Awarded	374	119	493
Value of Grants Awarded (Dollars in Millions)	$246.95	$127.94	$374.89
Patents Awarded	18	1	19
Patents pending	19	14	33

Data is self-reported by each project through annual reports and aggregated for the program, by year.

The table below indicates EPSCoR's ongoing support of human resources in STEM in the RII Track-1 and Track-2 program. The number of faculty and students involved in these projects signifies strong commitment by NSF and the jurisdictions in strengthening jurisdictional human capital in science and engineering research and education.

FY 2022 RII Track-1 and Track-2 Human Resource Development

	Track-1	Track-2	Total
Faculty Supported	1,025	543	1,568
Post-Docs Supported	194	123	317
Graduate Students Supported	1,089	471	1,560
Undergraduates Supported	1,175	360	1,535
New Faculty Hired	28	N/A	28
Graduate Degrees Conferred	141	42	183
Undergraduate Degrees Conferred	230	41	271

Data is self-reported by each project through annual reports and aggregated for the program, by year.

Along with EPSCoR, broadening participation is one of NSF's major initiatives. EPSCoR's goals reflect the efforts to broaden direct participation of diverse individuals, institutions, and organizations in

funded projects' STEM research and education activities. To that end, EPSCoR collects demographic data of project participants. The tables below reflect EPSCoR's ongoing support of FY 2022 broadening participation efforts in the RII Track-1 and Track-2 programs.

Out of over 4,000 project participants across the RII Track-1 projects, 90.7 percent self-identified their demographics. Of those, 46.9 percent were female, 24.6 percent were from one or more group traditionally underrepresented in STEM, and 1.2 percent were disabled. Out of over 1,600 project participants across the RII Track-2 projects, 90.0 percent self-identified their demographics. Of those, 42.7 percent were female, 18.2 percent were from one or more group traditionally underrepresented in STEM, and 1.9 percent were disabled.

RII Track-1 Broadening Participation

	Total*	Male	Female	African American	Hispanic or Latinx	Other Ethnic	Disabled
Faculty Supported	1,025	673	321	44	45	60	15
Technical Support Staff	209	108	87	8	11	12	1
Non-technical Support Staff	363	86	219	29	23	40	5
Post-Docs Supported	194	112	74	6	6	19	1
Graduate Students Supported	1,089	564	430	66	90	94	12
Undergraduates Supported	1,175	411	594	95	125	130	11
Total	**4,055**	**1,954**	**1,725**	**248**	**300**	**355**	**45**

* Aggregate demographics may not add to Total due to project participants who chose not to identify in one or more categories

RII Track-2 Broadening Participation

	Total*	Male	Female	African American	Hispanic or Latinx	Other Ethnic	Disabled
Senior Researchers	293	190	85	7	21	22	3
Early-career Researchers	250	135	101	11	16	13	1
Post-Docs Supported	115	70	33	4	9	2	5
Graduate Students Supported	473	264	173	31	30	22	9
Undergraduates Supported	348	126	159	22	24	12	7
Other Project Participants	136	48	69	12	4	3	3
Total	**1,615**	**833**	**620**	**87**	**104**	**74**	**28**

* Aggregate demographics may not add to Total due to project participants who chose not to self-identify in one or more categories.

Note: Demographic data available for 37 out of 43 active RII Track-2 awards in FY 2022.

Additionally, out of the 191 projects co-funded by EPSCoR, 70 percent of the PIs self-identified their demographics. Of those, 56 awards (32.2 percent) went to female PIs and 15 (7.8 percent) went to PIs from groups traditionally underrepresented in STEM.

NSF EPSCoR is continuing to refine and implement a cohesive research competitiveness evaluation framework for the program. The framework draws upon recommendations from a study completed

in FY 2020[2] that helped to develop a flexible framework to explore, define, and measure research competitiveness. The evaluation framework will also be informed by the Envisioning the Future of NSF EPSCoR report, published in 2022.

The evaluation framework, undergirded by the 2020 study and Future of NSF EPSCoR report, will: (1) help identify potential programmatic changes with respect to achieving the overall mission and increasing academic research competitiveness, and (2) produce a revised set of strategic priorities and an implementation plan that will leverage the current staffing capacity.

Additionally, EPSCoR secured a contract in FY 2022 to develop a new data collection system, which will help track project and programmatic progress in relation to EPSCoR's goals and objectives. This system builds upon the data collection efforts already in place. It will help the program to standardize the depth and breadth of information collected from all funded EPSCoR RII projects and will be used to measure capacity-building efforts within the research competitiveness evaluation framework for the program.

[2] Meek, Caroline, and Nisar, Hiram. 2020. Study of the Established Program to Stimulate Competitive Research (EPSCoR). Alexandria, VA: National Science Foundation.

NSF-WIDE INVESTMENTS

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

ADVANCE EMERGING INDUSTRIES

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

ADVANCE EMERGING INDUSTRIES FOR NATIONAL AND ECONOMIC SECURITY

Description and Rationale

For more than 70 years, NSF has supported fundamental and translational research across a broad range of science and engineering fields, enhancing U.S. national security, U.S. manufacturing and industrial productivity, and U.S. workforce development including addressing inequitable access to education, opportunity, and other services. NSF investment in high-risk, high-reward research has expanded human knowledge and unlocked entirely new technologies and industries. This has given rise to autonomous vehicles, revolutionary next-generation wireless networks and systems, novel computational platforms, life-saving medical devices, advanced manufacturing, and precision agriculture. NSF investment has also bolstered national and economic security both by catalyzing and sustaining leadership in pivotal technology focus areas, and by leveraging these technology advances in support of national security needs. Countless examples exist of NSF-funded breakthroughs that have been taken up by other agencies as part of their missions.

As the U.S. faces intensifying global competition for science and technology leadership, NSF is ready to strengthen and scale investments that advance breakthrough technologies, including innovation and translation. NSF's investment in Emerging Industries, one of its foundational pillars, includes advances in several Key Technology Focus Areas authorized in the CHIPS and Science Act that span (i) democratizing access to the infrastructure that researchers and students need to conduct in-the-wild experimentation of new concepts and capabilities; and (ii) harnessing the innovative spirit that exists in all corners of our country, which in turn allows anyone anywhere to pursue the jobs of the future and ensures sustained U.S. leadership for generations to come.

In FY 2024, NSF will accelerate advances in Emerging Industries by strengthening and scaling a dynamic, diverse, and well-coordinated portfolio of investments. As outlined below, NSF investments in FY 2024 will afford scaling of existing activities to accelerate outcomes and deepen impacts, while also launching new programs that will empower researchers and innovators to collaborate. Support for Key Technology Focus Areas that will drive Emerging Industries will come from across NSF.

Goal of Investment

NSF's portfolio in Emerging Industries aligns with its broader goals to energize the Nation's economic competitiveness, sustain our global leadership and resilience, expand the geography of innovation, and improve quality of life for everyone. Specifically, NSF will (i) advance science and engineering research and innovation leading to breakthrough technologies as well as solutions to national and societal challenges; (ii) accelerate the translation of fundamental discoveries from the lab to the market and society, advancing the U.S. economy; and (iii) create equitable education pathways to ensure every American can pursue high-wage, good-quality jobs.

Building on NSF's longstanding leadership in science and engineering research and education, a key focus will be to help Americans in all regions of the country develop and build new science- and engineering-driven innovation ecosystems that strengthen communities and address vital national needs. NSF will strengthen and scale the full spectrum of fundamental research, from foundational, discovery-oriented research to use-inspired, solution-oriented research in Emerging Industries. This includes advanced manufacturing, advanced wireless, artificial intelligence, biotechnology,

microelectronics and semiconductors, and quantum information science. A priority for this portfolio will be the development of partnerships that link academia, industry, government, philanthropy, investors, and civil society.

Potential for Impact, Urgency, and Readiness

The Nation faces a defining moment. Global competition for leadership and talent in science, engineering, and technology is at an all-time high. For the United States to remain a global leader, we must recommit to investing in research and innovation in breakthrough technologies, fostering dynamic new partnerships, and nurturing talent throughout the country, thereby encouraging the innovative spirit that has been the source of our leadership over the past seven decades. Investing now in research, innovation, and education will ensure the Nation's continued leadership in vital industries for decades to come. The Internet, Google, Qualcomm, 3D printing, and economic theory underpinning spectrum auctioning and kidney exchanges all serve as examples of the outcomes and benefits of NSF investments. The technologies and industries that are the focus of national conversations around competitiveness today, and the ones that will emerge in the future, are rooted in sustained NSF support for research and innovation at the frontiers of science and engineering.

In FY 2024 areas that NSF will catalyze and support research and innovation in Emerging Industries through investments that address include the following:

- **Advanced Manufacturing** (including robotics and automation) investments will accelerate breakthroughs in manufacturing materials, technologies, and systems through fundamental, multidisciplinary research that transforms manufacturing capabilities, methods, and practices. NSF investments will further advanced manufacturing through advanced energy and industrial efficiency technologies, resilient manufacturing strategies, novel methods in engineering biology, next-generation materials, and the power of data science, automation, robotics, and machine learning to intelligently design and develop future approaches that are secure, sustainable, and resilient to natural and anthropogenic disasters.
- **Advanced Wireless** (including communications technology and immersive technology) investments will advance knowledge gaps and innovations in areas critical to future generations of communications technologies and networks, such as wireless devices, circuits, protocols, and systems; mobile edge computing; distributed machine learning and inference on mobile devices; human-machine-network interactions; and dynamic spectrum allocation and sharing, while ensuring innovation and security for all users. For example, this investment will serve to advance both new active spectrum applications and spectrum used for non-commercial purposes, such as advanced receiver design and interference mitigation techniques for radio astronomy and atmospheric science. NSF investments will provide the backbone that connects users, devices, applications, and services that will continue to enrich America's national and economic security.
- **Artificial intelligence** (including machine learning, autonomy, and related advances) investments will bring together numerous fields of scientific inquiry—including computer and information science; cognitive science and psychology; economics and game theory; education research; engineering and control theory; ethics; linguistics; mathematics; and philosophy—to advance the frontiers of trustworthy AI, including advancing perception, learning, reasoning, recommendation, and action in the context of specific fields and economic sectors. NSF investments are needed to develop new foundational AI theory and implementation techniques, as well as novel AI methods that are inspired by use cases in specific application domains and contexts.

- **Biotechnology** (including genomics and synthetic biology) investments will support fundamental research, infrastructure, and education to understand and harness biological processes for societal benefit. It will propel advances in genomics, bioinformatics and data analytics, structural and computational biology, biophysics, synthetic and engineering biology, tissue and metabolic engineering, medical technology, development of new types of biomaterials, bio-inspired data storage and microelectronics, and biomanufacturing, as well as accelerate the ability to harness biological systems to create goods and services that contribute to agriculture, health, security, manufacturing, and resilience to climate change, including natural and anthropogenic disaster prevention and mitigation. As part of the National Engineering Biology Research and Development Initiative codified in the CHIPS and Science Act, NSF investments in research at the intersection of the biological, physical, chemical, data, computational and information sciences and engineering, and social, behavioral and economic sciences will accelerate scientific understanding and technological innovation in engineering biology as well as assure public acceptance of the products of engineering biology.
- **Microelectronics and semiconductors** (including advanced computer hardware) investments will address the microelectronics and semiconductor challenges facing our Nation due to technological and global trends, such as the end of Moore's Law and offshoring of semiconductor fabrication and manufacturing, by supporting work in semiconductor discovery, development, and fabrication, leading to future domestic and related electronics foundries, as well as the design ecosystem of secure microelectronic systems and devices based on them. These investments will enable future advanced computing systems, including quantum computing and networking technologies. Investments will also advance next-generation materials and highly parallel chip designs that will improve the performance of AI algorithms as well as integrate advanced energy efficiencies for low-power and high-performance devices that will drive a mobile and wireless future, and smart sensors that will interface between biosystems and electronics. Additionally, the CHIPS and Science Act provides NSF with $200 million over five years for microelectronics workforce development activities, and the Foundation is in the process of reviewing the requirements of the legislation and developing a spend plan for FY 2023 through FY 2027.
- **Quantum information Science** investments will pioneer development of quantum computing, communication, sensing, and networking to advance information processing, transmission, and measurement in ways that classical approaches can only do much less efficiently, or not at all. This investment will develop proof-of-concept devices, tools, systems, and applications with a demonstrable quantum advantage over their classical counterparts. For example, investments in research on quantum sensors will enhance resolution and detection capabilities.

The parameters of NSF's investments in the Emerging Industries in FY 2024 are informed by findings from major reports, reviews, evaluations, and other evidence-building techniques. Some include:

<u>Advanced Manufacturing</u>

The *2022 National Strategy for Advanced Manufacturing*[1] provides a vision for U.S. leadership in advanced manufacturing. Manufacturing is essential to almost every sector of the U.S. economy, spurring growth by increasing productivity, enabling new products, and opening new industries. Rather than constrain the innovative solutions of tomorrow to the manufacturing methods we use today, we must push forward the frontiers of manufacturing to unleash and realize our national economic potential. NSF's investment in advanced manufacturing will continue to grow our nation's

[1] www.manufacturingusa.com/reports/national-strategy-advanced-manufacturing

workforce, enhance supply chain resilience, and create products and processes with higher performance, fewer resources, and/or new capabilities.

Advanced Wireless

NSF co-chaired the formulation of a 2021 *National Strategy to Secure 5G Implementation Plan*[2], which noted that fifth generation ("5G") wireless networks will drive our Nation's prosperity and security in the 21st century. Next-generation wireless networking will spur innovation and enable the development of new markets, products, and services, thereby contributing to economic growth. Of particular importance in the Implementation Plan was the need to invest in the security and resiliency of these networks. NSF's Resilient and Intelligent Next-Generation Systems (RINGS) program, in collaboration with two other federal agencies and nine companies, is directly aligned with this emphasis.

Artificial Intelligence

The NSF Director co-chairs the Select Committee on AI, which advises the White House on interagency AI R&D priorities and establishes structures to improve government planning and coordination. In June 2019, the Select Committee on AI issued an update to the *2016 National Artificial Intelligence Research & Development (AI R&D) Strategic Plan*[3]. The *National AI R&D Strategic Plan: 2019 Update*[4], identified eight strategic priorities and provided a coordinated federal strategy for AI R&D to ensure that the United States continues to lead the world in cutting-edge advances in AI that grow our economy, increase our national security, and improve our quality of life. NSF is also co-leading an anticipated 2023 update to the strategic plan, and, in general, NSF's activities in AI research, education, and research infrastructure are directly aligned with the federal AI R&D strategy.

A PCAST report on *Recommendations for Strengthening American Leadership in Industries of the Future* (June 2020)[5] recommended that federal agencies partner with industry and academia to ensure the effective transition and translation of early-stage research outcomes into applications at scale. This report helped to inform expansion of the NSF National AI Research Institutes program to include industry partners. A subsequent 2021 PCAST report, *Industries of the Future Institutes: A New Model for American Science and Technology Leadership* (January 2021)[6] builds upon this strategy for convergent AI research, emphasizes the ubiquitous role of AI in societal challenges, and situates the National AI Research Institutes program as a long-term multi-sector initiative to enhance innovation through foundational and use-inspired research.

The National AI Initiative Act of 2020[7] called on NSF in coordination with OSTP to form a National AI Research Resource (NAIRR) Task Force to investigate the feasibility of establishing a NAIRR and develop a roadmap detailing how such a resource could be established and sustained. Comprising

[2] www.ntia.gov/files/ntia/publications/2021-1-12_115445_national_strategy_to_secure_5g_implementation_plan_and_annexes_a_f_final.pdf
[3] www.nitrd.gov/pubs/national_ai_rd_strategic_plan.pdf
[4] www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf
[5] https://science.osti.gov/-/media/_/pdf/about/pcast/202006/PCAST_June_2020_Report.pdf?la=en&hash=019A4F17C79FDEE5005C51D3D6CAC81FB31E3ABC
[6] https://science.osti.gov/-/media/_/pdf/about/pcast/202012/PCAST---IOTFI-FINAL-Report.pdf?la=en&hash=0196EF02F8D3D49E1ACF221DA8E6B41F0D193F17
[7] www.congress.gov/116/crpt/hrpt617/CRPT-116hrpt617.pdf#page=1210

members from government, academia, and the private sector, the NAIRR Task Force submitted its final report to the President and Congress, *Strengthening and Democratizing the U.S. Artificial Intelligence Innovation Ecosystem: An Implementation Plan for a NAIRR* in January 2023[8]. The report offers an implementation plan for the NAIRR that would build on existing and future Federal investments. In FY 2024, NSF will focus on the implementation of the recommendations in the NAIRR report.

Biotechnology

President Biden's Executive Order on *Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy*[9] laid out a whole-of-government approach to advance biotechnology and biomanufacturing towards innovative solutions to keep the U.S. healthy and secure. Among its directives, the National Science Foundation was charged with identifying bold goals and cross-cutting research and development needs that, if fully funded, would provide the foundational discoveries, innovations, and infrastructure essential to advance all sectors of the bioeconomy. Additional reports associated with the Executive Order identify key needs in workforce development, data and associated infrastructure, and manufacturing innovation needed to advance the U.S. bioeconomy. The focus on biotechnology to advance the U.S. bioeconomy aligns with the theme area of emerging industries and the Administration's focus on economic recovery. Investments in this area will allow translating knowledge and tools into applications that promote the U.S. bioeconomy in public health, agriculture, energy, climate change, and security.

Microelectronics/Semiconductors

Microelectronics and semiconductors are omnipresent in transportation, communications, healthcare, manufacturing, information technology, and other industries. However, as noted in the CHIPS and Science Act, U.S.-led innovations in semiconductors and microelectronics have slowed, the Nation is facing unprecedented global competition, and the building blocks of today's microelectronics, which rely on scarce natural resources, are approaching fundamental limits in both size and energy efficiency. New paradigms of both capabilities and sustainability are needed for future microelectronics and semiconductors, as well as a strong domestic workforce.

Quantum Information Science

NSF's QIS Investments are influenced by the analyses and recommendations included in a series of NSTC reports. Among these are: *Quantum Frontiers Report, A Coordinated Approach to Quantum Networking Research, The Role of International Talen in Quantum Information Science, the QIST Workforce Development National Strategic Plan, and Bringing Quantum Sensors to Fruition.*[10]

Anticipated Potential Contributors

NSF's investments in FY 2024 will reflect an integrated portfolio allowing for rapid acceleration not just within each of the above areas but also at the intersections between them. Funding will allow support for a broad suite of programs to advance research and innovation in key technology focus areas across all NSF directorates and offices through strategic partnerships with other federal agencies and

[8] www.ai.gov/wp-content/uploads/2023/01/NAIRR-TF-Final-Report-2023.pdf

[9] www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy/

[10] All reports can be accessed via www.quantum.gov

the private sector. Increases will afford strengthening and scaling of NSF's substantial existing investment in Emerging Industries as well as initiating significant new initiatives.

ADVANCED WIRELESS RESEARCH

Advanced Wireless Funding[1]

(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
CISE	$89.45	$88.76	-	-	$88.76	$93.26
ENG	26.00	25.00	-	-	25.00	27.75
MPS	17.00	17.00	-	-	17.00	17.00
TIP	30.00	15.62	7.64	7.29	30.55	41.16
Total	**$162.45**	**$146.38**	**$7.64**	**$7.29**	**$161.31**	**$179.17**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actual may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Overview

Advanced wireless networks and systems will provide the backbone that connects users, devices, applications, and services that will continue to enrich America's economy. NSF has a proven track record of investing in fundamental research on wireless technologies. For example, today's fifth-generation ("5G") wireless networks and systems have been enabled by ground-breaking NSF-funded research on millimeter-wave capabilities, advanced antenna systems, and other novel algorithms and protocols dating back to 2004. NSF partners with other federal agencies and industry on such research. Looking forward, NSF-supported research will innovate in areas critical to future generations of wireless networks and systems, such as new wireless devices, circuits, protocols, and systems for "6G" and beyond; security and resiliency; mobile edge computing; distributed machine learning, and inferences across mobile devices; and fine-grained and real-time dynamic spectrum allocation and sharing. This research will offer new insights capable of making wireless communication faster, smarter, resilient, more affordable, more robust and secure and integrated with efficient sensing (e.g., forming radio images based on the reflections from wireless signals).

NSF co-chaired the formulation of a 2021 *National Strategy to Secure 5G Implementation Plan*[1], which noted that fifth-generation ("5G") wireless networks will drive our Nation's prosperity and security in the 21st century. Next-generation wireless networking will spur innovation and enable the development of new markets, products, and services, thereby contributing to economic growth. Of particular importance in the 5G Implementation Plan was the need to invest in the security and resiliency of these networks. NSF's Resilient and Intelligent Next-Generation Systems (RINGS) program, in collaboration with two other federal agencies and nine companies, is directly aligned with this emphasis. In addition, by deepening public and private partnerships through programs like RINGS and Platforms for Advanced Wireless Research (PAWR), NSF will accelerate the lab-to-market translation of innovative research outcomes in academic and government labs to successful products and services for the benefit of society.

[1]www.ntia.gov/files/ntia/publications/2021-1-12_115445_national_strategy_to_secure_5g_implementation_plan_and_annexes_a_f_final.pdf

Goals

NSF's leadership in wireless research has three intertwined components:

1. *Fundamental Research on Advanced Wireless:* Support fundamental research enabling the conception, exploration, and development of advanced wireless technologies.
2. *Advanced Wireless Research Testing Platforms:* Establish advanced wireless research testing platforms, in collaboration with industry, to experiment with new technologies at scale and to generate data sets that can be used by the research community to validate proposed methods and techniques at earlier stages of development.
3. *Education and Workforce Development:* Catalyze academic, industry, and community leaders to work together to nurture the next generation of the wireless and spectrum workforce, including researchers, engineers, technicians, and practitioners, as well as to increase public awareness of advanced wireless.

FY 2024 Investments

<u>Fundamental Advanced Wireless Research</u>

- Through foundational research programs in CISE and ENG, outcomes from NSF investments in advanced wireless over the last decade have enabled 5G deployments capable of delivering multi-gigabit-per-second (Gbps) bandwidth to individual wireless users. Continued investments in advancing these frontiers are focused on developing advanced technologies to support ultra-low latencies of the order of sub-milliseconds while simultaneously connecting hundreds of millions of devices. Moreover, NSF foundational research programs coupled with investments by TIP in use-inspired and translational research are also investing in technologies beyond 5G systems, developing more efficient uses of spectrum bands, higher-order spectrum, spectrum sharing, sensing using wireless communications, and novel codes for highly-efficient device-to-device communications as well as improving resilience and security of wireless networks. These investments will continue to support the foundations of U.S. leadership in advanced wireless R&D.
- In FY 2024, in partnership with the Department of Defense (DOD) Undersecretary of Defense for Research and Engineering (OUSD (R&E)), the National Institute of Standards and Technology (NIST), and nine industry partners, NSF will continue to support the RINGS program, laying the groundwork for next-generation wireless connections that will enable faster service; resiliency to natural disasters, malicious attacks, and service interruptions; and broader access to wireless connectivity for people across the U.S.
- In FY 2024, NSF will support, in collaboration with DOD OUSD (R&E), use-inspired research on 5G security through a track of the Convergence Accelerator, Securely Operating Through 5G Infrastructure. The goal of this track is to enhance end devices and/or augment 5G infrastructure to enable military, government, and critical infrastructure operators to have the capability to operate through public 5G networks, while meeting security and resilience requirements.
- In FY 2024 NSF will continue its support for the NSF AI Institute for Edge Computing Leveraging Next-generation Networks (Athena) and the NSF AI Institute for Future Edge Networks and Distributed Intelligence (AI-Edge). Athena focuses on developing edge computing with groundbreaking AI functionality while keeping complexity and costs under control. AI-Edge leverages the synergies between networking and AI to design future generations of wireless edge networks that are highly efficient, reliable, robust, and secure.
- NSF investments in fundamental advanced wireless research will be in synergy with the National Center for Wireless Spectrum Research (SII-Center) program under the Spectrum Innovation

Initiative (SII) which also invests in the National Radio Dynamic Zones (SII-NRDZ) program. SII-NRDZ is an interdisciplinary program that seeks to foster collaborations among stakeholders to advance the use of dynamic spectrum sharing for the enhancement of active electromagnetic spectrum management efforts at NSF's major research facilities and platforms.

Advanced Wireless Research Testing Platforms

- NSF is pursuing a convergent approach to validate advanced wireless research through its PAWR program, a $100.0 million public-private partnership comprising $50.0 million of NSF investment paired with $50.0 million in funding and in-kind contributions from a wireless consortium of 35 companies. With oversight from the NSF-funded PAWR Project Office hosted at US Ignite, Inc., and Northeastern University, PAWR platforms in Salt Lake City, UT; West Harlem, NY; Research Triangle, NC; and Ames, IA, are helping to build core wireless capabilities through creative university partnerships, attracting government and corporate research funding as well as local wireless jobs, and using advanced wireless capabilities to enhance community services and economic development. FY 2024 will be the third year when all four PAWR testbeds are fully operational and generally available simultaneously to the research community, unleashing the full potential of translational opportunities for advanced wireless R&D. Moreover, NSF investments through TIP will allow federation of an open-access plane across the four PAWR testbeds, creating an interconnected national network for testing and validation of emerging wireless concepts.
- The PAWR testbeds will continue to benefit from NSF investments in the NSF National Radio Dynamic Zone program under the SII. In FY 2024, the PAWR testbeds will support proofs of concept for dynamic spectrum sharing across diverse geographic and spectrum use cases.
- In FY 2024, NSF will support multiple cross-directorate programs (potentially as public-private partnerships) to support research in advanced networking systems. The programs built through these partnerships will seek innovations in networking for connected medical systems, machine learning for high-performance, next-generation networks, airborne and satellite networking, and novel radio frequency spectrum uses. The programs are expected to fund collaborative team research that transcends the traditional boundaries of individual disciplines to achieve the program goals.

Education and Workforce Development

- In FY 2024, NSF will continue emphasizing the need to develop a workforce trained in advanced wireless technologies, which is critical to maintaining U.S. leadership in advanced wireless. Through ongoing investments in programs such as Research Experiences for Undergraduates, Research Experiences for Teachers in Engineering and Computer Science, Computer Science for All: Researcher Practitioner Partnerships, Improving Undergraduate STEM Education: Computing in Undergraduate Education, Experiential Learning for Emerging and Novel Technologies (ExLENT), NRT, and GRFP as well as the SII-Center, NSF will continue to train future generations of scientists, engineers, and practitioners to pursue careers in this domain.

ADVANCED MANUFACTURING

Advanced Manufacturing Funding[1]

(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$7.16	$7.16	-	-	$7.16	$7.16
CISE	45.24	44.30	-	-	44.30	44.40
EDU	12.37	6.00	-	-	6.00	6.00
ENG	129.00	125.00	-	-	125.00	184.37
MPS	162.30	128.33	-	-	128.33	133.33
SBE	0.50	0.50	-	-	0.50	3.50
TIP	54.00	27.94	13.66	13.04	54.64	73.60
OISE	0.02	0.50	-	-	0.50	0.50
IA	15.60	1.00	-	-	1.00	1.00
Total	**$426.19**	**$340.73**	**$13.66**	**$13.04**	**$367.43**	**$453.86**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actual may be greater that future fiscal years due to the receipt of more meritorious proposals than expected.

Overview

Manufacturing is essential to almost every sector of the U.S. economy, spurring the economy by increasing productivity, enabling new products, and opening new industries. Advanced manufacturing uses innovative technologies to create safe and secure products and processes with higher performance, fewer resources, and/or new capabilities. NSF programs accelerate advances in manufacturing materials, technologies and systems through fundamental, multidisciplinary research that transforms manufacturing capabilities, methods, and practices.

Since its founding in 1950, NSF has pushed the frontiers of manufacturing, sparking breakthroughs from nanomaterials and computer-aided design to 3D printing and blockchain, as well as tools for real-time, in situ feedback and sensing. NSF investments in advanced manufacturing have increased and will continue to increase U.S. prosperity, as well as the Nation's competitiveness, security, and quality of life (as measured through a growing advanced manufacturing workforce and translation of discovery to useful products).

Today, NSF continues to invest in fundamental research to create new, safe, secure, and sustainable capabilities for chemical and materials synthesis and processing; fabrication and manufacturing of advanced semiconductors, quantum devices, and optical devices; discovery and manufacture of alternative materials with lower climate and environmental impacts; distributed and smart manufacturing systems; safe, productive, privacy-preserving, and collaborative worker-technology interactions; the ethical, social, economic, and legal consequences of advanced manufacturing; and broad advanced manufacturing discovery. NSF invests in communities and experiential programs to

grow and nurture a STEM-enabled manufacturing workforce and in industry partnerships and entrepreneurship to speed manufacturing innovations to the marketplace.

NSF's advanced manufacturing research intersects, builds upon, and contributes to related investments in biotechnology, sustainability, microelectronics and semiconductors, artificial intelligence, robotics, sensing technologies, the Internet of Things, data science, and computational modeling. Similarly, NSF's investments in Clean Energy, Climate Change and Emerging Technologies are bolstered by advanced manufacturing research.

Goals

1. *Advanced Manufacturing Research*: Support groundbreaking discoveries for advanced manufacturing that lead to products and processes with higher performance, new capabilities, better safety, security and privacy guarantees, and the use of fewer and more-sustainable resources.
2. *Future Manufacturing Research*: Increase knowledge in emerging areas to enable a new generation of manufacturing industries that do not exist today, that are compatible with human needs, that make U.S. manufacturing competitive far into the future, and that build in resilience to global disruptions for the Nation's manufacturing infrastructure.
3. *Workforce Development*: Attract, educate, train and reskill/upskill diverse workers, from K-12 to college and industry, across the Nation, for the manufacturing workforce of the future.
4. *Translation to Practice*: Leverage partnerships with other sectors to enable the translation of research results to the market and society.

FY 2024 Investments

<u>Advanced Manufacturing Research</u>
Continued investments in advanced manufacturing include the discovery of new methods, processes, analyses, tools, or equipment for new or existing manufacturing products, supply-chain components, or chemicals and materials, including replacements for environmentally harmful mainstay materials such as plastics. NSF also supports research in next-generation manufacturing infrastructure as part of a broader effort to design and renew national infrastructure.

<u>Future Manufacturing Research</u>
Initiated in FY 2020, the Future Manufacturing investment advances fundamental research to enable manufacturing that (a) does not exist or is not possible today, or (b) exists or is possible only at such small scales that it is not yet viable for mass production. Investments focus on cyber-, eco- and bio-manufacturing research advances. The Future Manufacturing activity will add a new emphasis on Human-Centered Automation using former FW-HTF funds.

<u>Workforce Development</u>
To prepare a diverse advanced manufacturing workforce, NSF invests in the Advanced Technological Education, Faculty Early Career Development, Engineering Research Initiation, Grant Opportunities for Academic Liaison with Industry, Sites and Supplements for both Research Experiences for Undergraduates and Research Experiences for Teachers programs, as well as in manufacturing engineering education in research projects. NSF support for Non-Academic Research Internships for Graduate Students (INTERN) provides individuals with experiences in other sectors, including industry

and government. NSF-supported access to fabrication and manufacturing facilities, such as NNCI, semiconductor foundries and Manufacturing USA Institutes, provides students across the Nation with training and professional development for careers in advanced manufacturing.

Translation to Practice

NSF speeds translation of fundamental discoveries in advanced manufacturing into products and processes through its Engineering Research Centers, Industry-University Cooperative Research Centers, and through its BioFoundries in BIO, as well as the NSF Lab-to-Market Platform and other activities in TIP. In addition, NSF coordinates with other agencies (e.g. DOE Agile Biofoundry consortium) and participates in the Manufacturing USA Institutes, particularly by connecting them to universities and community colleges.

ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence Funding[1]

(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$20.00	$20.00	-	-	$20.00	$20.00
CISE	346.96	344.00	-	-	344.00	389.00
EDU	59.61	35.00	-	-	35.00	42.50
ENG	88.00	88.00	-	-	88.00	97.00
GEO Programs	1.00	5.00	-	-	5.00	5.00
MPS	134.18	75.21	-	-	75.21	84.20
SBE	17.74	16.92	-	-	16.92	19.59
TIP	100.00	52.45	25.64	24.48	102.57	138.19
IA	14.30	1.00	-	-	1.00	1.00
Total	**$781.79**	**$637.58**	**$25.64**	**$24.48**	**$687.70**	**$796.48**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actual may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Overview

AI is advancing rapidly and is increasingly demonstrating its potential to significantly transform our lives. NSF has a long and rich history of supporting AI research, setting the stage for today's widespread use of AI technologies in a range of sectors, from commerce to healthcare to transportation. NSF-funded research is now laying the foundation for advances in AI that will transform not just these areas, but essentially every area of human endeavor, including science, education, energy, manufacturing, and agriculture. NSF's AI portfolio spans AI algorithms, robotics, human-AI interaction, and advanced cyberinfrastructure for AI, as well as use-inspired research in neuroscience, biology, chemistry, physics, intelligent transportation, and many other disciplines across the full breadth of science and engineering in which NSF invests.

NSF supports fundamental research, education and workforce development, and access to data and advanced computing research infrastructure that collectively enhance AI. NSF's ability to bring together numerous fields of scientific inquiry uniquely positions the agency to lead the Nation in expanding the frontiers of AI. In FY 2024, NSF will continue support for foundational research in AI, including machine learning (ML) and deep learning, natural language technologies, knowledge representation and reasoning, robotics, and computer vision, along with fairness, ethics, accountability, transparency, explainability, safety, security, and robustness across all areas of AI. In addition to foundational research in these areas, NSF also supports use-inspired and translational research that links AI innovation with science and the economy, including agriculture, manufacturing, biotechnology, and health. Equally important is NSF's investment in education and learning, which grows the human capital and institutional capacity needed to nurture the next generation of AI

researchers and practitioners as well as AI technology in support of learning more broadly. Finally, advances in AI rely upon access to data as well as NSF-funded advanced computing research infrastructure.

Through collaboration and coordination with the Office of Science and Technology Policy (OSTP), NSF leadership is helping to drive and coordinate AI R&D efforts across the federal government. For example, the NSF Director co-chairs the National Science and Technology Council's (NSTC) Select Committee on AI, which advises the White House on interagency AI R&D priorities and establishes structures to improve government planning and coordination. In addition, NSF co-chairs the NSTC Machine Learning and AI (MLAI), NSTC Networking and Information Technology R&D (NITRD), and NSTC Future Advanced Computing Ecosystem (FACE) Subcommittees, as well as the more AI-focused R&D Interagency Working Group, all of which serve to coordinate federal R&D investments in AI as well as other related information technology areas, including the underlying advanced computing ecosystem that is critical for advancing AI.

In June 2019, the NSTC Select Committee on AI issued an update to the *2016 National Artificial Intelligence Research & Development (AI R&D) Strategic Plan*[1]. NSF was a key contributor to the *National AI R&D Strategic Plan: 2019 Update*[2], which identified eight strategic priorities and provided a coordinated federal strategy for AI R&D to ensure that the United States continues to lead the world in cutting-edge advances in AI that grow our economy, increase our national security, and improve our quality of life. NSF is also a key contributor to an anticipated 2023 update to the AI R&D strategic plan, and, in general, NSF's activities in AI research, education, and research infrastructure are directly aligned with this strategic plan update.

A PCAST report on *Recommendations for Strengthening American Leadership in Industries of the Future* (June 2020) recommended that federal agencies partner with industry and academia to ensure the effective transition and translation of early-stage research outcomes into applications at scale. This report helped to inform the expansion of the NSF National AI Research Institutes program to include industry partners. A subsequent 2021 PCAST report, *Industries of the Future Institutes: A New Model for American Science and Technology Leadership* (January 2021) builds upon this strategy for convergent AI research, emphasizes the ubiquitous role of AI in societal challenges, and situates the National AI Research Institutes program as a long-term multi-sector initiative to enhance innovation through foundational and use-inspired research.

The National AI Initiative Act of 2020[3] called on NSF in coordination with OSTP to form a National AI Research Resource (NAIRR) Task Force to investigate the feasibility of establishing a NAIRR and develop a roadmap detailing how such a resource could be established and sustained. Comprising members from government, academia, and the private sector, the NAIRR Task Force submitted its final report to the President and Congress, *Strengthening and Democratizing the U.S. Artificial Intelligence Innovation Ecosystem: An Implementation Plan for a NAIRR* in January 2023[4]. The report offers a roadmap and implementation plan for the NAIRR that would build on existing and future Federal investments.

[1] www.nitrd.gov/pubs/national_ai_rd_strategic_plan.pdf
[2] www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf
[3] www.congress.gov/116/crpt/hrpt617/CRPT-116hrpt617.pdf#page=1210
[4] www.ai.gov/wp-content/uploads/2023/01/NAIRR-TF-Final-Report-2023.pdf

Goals

NSF's leadership in AI has three intertwined components:

1. *Fundamental AI Research:* Sustain long-term investments in fundamental AI research that will give rise to transformational technologies and, in turn, breakthroughs across all areas of science and engineering and across all sectors of society.
2. *Education and Workforce Development:* Develop AI systems that enhance learning for all and grow the next generation of talent to advance the U.S. AI R&D workforce, including those working on AI systems and those working alongside them.
3. *Access to Data and Advanced Computing Research Infrastructure:* Provide access to advanced cyberinfrastructure including scalable computing resources as well as deep, high-quality, and accurate training datasets to advance AI research and education.

FY 2024 Investments

<u>Fundamental AI Research</u>

- In FY 2024, NSF will continue support for the National AI Research Institutes program that was initiated in FY 2019 to create national hubs for universities, federal and local agencies, industry, and nonprofits to advance AI research and workforce development in key areas addressing grand challenges. In FY 2020 and FY 2021 NSF funded 14 institutes in themes that included foundations of ML; trustworthy AI; AI-augmented learning; AI for accelerating molecular synthesis and manufacturing; human-AI interaction and collaboration; AI and advanced cyberinfrastructure and AI for discovery in physics. Each AI Institute receives up to $20.0 million over five years. NSF also partnered with the U.S. Department of Agriculture National Institute of Food and Agriculture (USDA NIFA) to establish two additional institutes in each of FY 2020 and FY 2021, advancing AI-driven innovation in agriculture and food systems; these four AI Institutes are being fully supported by USDA NIFA. NSF issued the latest solicitation in Fall 2021 and anticipates making up to seven awards in FY 2023, bringing the total number of institutes funded to 25. This solicitation continues the ongoing collaboration with USDA NIFA and the Department of Homeland Security, Science and Technology Directorate (DHS S&T) as well as new partnerships with the Department of Defense Office of the Undersecretary of Defense for Research and Engineering (DOD OUSD(R&E)), National Institute of Standards and Technology (NIST), Department of Education Institute for Education Sciences (IES), and IBM Corporation. In FY 2024, NSF and its partners will begin evaluating the first institutes for possible renewal.
- NSF began a new initiative called Expanding AI Innovation through Capacity Building and Partnerships (ExpandAI). This effort is designed to support the continued growth of a broad and diverse interdisciplinary research community for the advancement of AI and AI-powered innovation. The ExpandAI program aims to significantly broaden participation in AI research, education, and workforce development through capacity development projects and through partnerships within the National AI Research Institutes ecosystem. ExpandAI also includes partnerships with other federal agencies (DHS, DOD, NIST, USDA NIFA, and DOD).
- In FY 2023, NSF began a targeted effort to enhance research in safety of AI systems that operate autonomously, in partnership with Open Philanthropy and Good Ventures. The Safe Learning-Enabled Systems program aims to create a community of researchers who collaborate on the topics of design and implementation of safe learning-enabled systems; methods for rigorously reasoning (including probabilistically/statistically/logically) about safety amid uncertainty (in data, environment observations, system calibration, etc.); and machine learning. The desired outcome

is that future safe learning-enabled systems will be constructed with sound design principles which practitioners can leverage to achieve safety specifications.

- In FY 2020, NSF, in collaboration with the Simons Foundation, funded two five-year collaborative projects on the Mathematical and Scientific Foundations of Deep Learning. Interdisciplinary teams of computer scientists, engineers, mathematicians, and statisticians will advance theoretical and foundational investigations into deep learning, with a view to laying the groundwork for a rigorous science of deep learning. In FY 2024, NSF will continue support for these centers. In addition, beginning in FY 2021 and continuing for three years, NSF is supporting more than a dozen smaller-scale projects seeking to advance the mathematical and scientific foundations of deep learning.
- In FY 2024, through the Foundational Research in Robotics (FRR) program, CISE and ENG will continue to support robotics research that combines advances in engineering with innovations in computer science. The FFR program invests in robotics and autonomous systems that exhibit significant levels of computational capability and physical complexity, including research related to the design, application, and use of robotics to augment human function, promote human-robot interaction, and increase robot autonomy, many of which depend critically on AI approaches.
- The NSF Convergence Accelerator program has emphasized AI through a variety of themes dating back to FY 2020. For example, in FY 2021, the program invested in a set of projects focused on AI-Driven Innovation via Data and Model Sharing. Similarly, in FY 2022, the program emphasized AI through themes on the development of innovative assistive or rehabilitative technologies to help improve equity, inclusion, and accessibility for persons with disabilities; informatics for sustainable materials; and modeling and prediction to address food and nutrition security.
- In FY 2023 and FY 2024, as an outgrowth of a Convergence Accelerator program track on Open Knowledge Networks (OKN), and following an OKN Innovation Sprint co-led by NSF and the White House Office of Science and Technology Policy, NSF together with multiple other federal agencies will invest in the development of a prototype OKN — an interconnected network of knowledge graphs supporting a very broad range of application domains. Open access to shared information, as afforded by the prototype OKN, is essential to the development and evolution of AI and AI-powered solutions needed to address complex challenges facing the Nation.

<u>Education and Workforce Development</u>

- As noted above, in FY 2020, NSF established a five-year National AI Research Institute for AI-augmented learning to radically improve human learning and education writ large in formal (e.g., preK-12, undergraduate, graduate, vocational education) and informal settings. In FY 2021, NSF established two additional five-year National AI Research Institutes in AI and Education. The primary focus of these institutes is to support AI-driven innovation to improve human learning and education. One AI Institute is pursuing research to support highly adaptable, personalized, and distributed AI systems to expand STEM learning across diverse learners and settings in the context of preK-12 education. The other Institute is advancing AI-driven research and innovations for learners with or at risk for disabilities. Both AI Institutes are addressing achievement and opportunity gaps, particularly for learners from disadvantaged or underserved communities and pursue outcomes with direct educational impact.
- In partnership with the Department of Education's Institute of Education Sciences, NSF established a five-year AI Institute for Exceptional Education that will focus on the speech language pathology needs of children. This AI institute aims to address the increasing need, exacerbated by the COVID-19 pandemic, for the availability of speech and language services for children. The AI Institute will develop advanced AI technologies to scale speech-language pathologists' availability and services

such that no child in need of speech and language services is left behind.

- NSF will address a critical shortage of cybersecurity educators and researchers in priority areas including the cybersecurity aspects of AI as well as AI for cybersecurity, through the Education track in the SaTC program as well as the CyberCorps®: Scholarship for Service (SFS) program.
- As authorized by the CHIPS and Science Act, NSF will submit to Congress a report on the need and feasibility to implement an AI Scholarship-for-Service program to recruit and train the next generation of AI professionals to meet the needs of federal, state, local and tribal governments. The report will include an assessment of the capacity of institutions of higher education to produce graduates with degrees, certifications, and relevant skills related to AI.
- In FY 2024, GRFP will continue to encourage applications from students who are interested in pursuing AI-related research. The NSF GRFP recognizes and supports outstanding graduate students in NSF-supported STEM disciplines who are pursuing research-based master's and doctoral degrees at accredited U.S. institutions.
- The NRT program advances graduate education by combining interdisciplinary training with innovative professional development activities to educate the next generation of scientists and engineers capable of solving convergent research problems in areas of national need. In FY 2024, NRT will continue to include a special focus on traineeships in AI and other emerging industries that align with the Administration's priorities.
- In FY 2024, NSF's Computer Science for All (CSforAll) and Innovative Technology Experiences for Students and Teachers (ITEST) programs will continue to support projects that investigate promising educational approaches at the K-12 level to motivate and prepare a diverse cadre of learners for computationally intensive new industries, including those that that rely on AI.[5]
- In FY 2024, NSF will continue to support Data Science Corps in collaboration with philanthropic partners. This program enables education and workforce development by focusing on building capacity at the local, state, and national levels to unleash the power of data in service to society. Data Science Corps provides practical experiences, teaches new skills, and offers learning opportunities in a range of settings.

<u>Access to Data and Advanced Computing Research Infrastructure</u>

- In FY 2024, NSF will focus on the implementation of the recommendations in the NAIRR Task Force's final report, mentioned above, to amplify efforts across the federal government to cultivate AI innovation and advance trustworthy AI. The NAIRR is envisioned as a widely-accessible, national cyberinfrastructure that will advance and accelerate the U.S. AI R&D environment and fuel AI discovery and innovation in the United States. Specifically, NSF will work with other federal agencies and the broader community on the NAIRR Pilot Option outlined in the report to provide pilot-scale access to existing computational resources, software, datasets, services, and user portals across the current national cyberinfrastructure ecosystem.
- NSF supports a range of advanced computing systems and services for the full range of computational- and data-intensive research across all areas of science and engineering, including AI. For example, Frontera, the largest and most powerful supercomputer NSF has ever supported, will enable access to advanced computing resources for AI research. Furthermore, NSF will support innovative prototype systems such as Neocortex and Voyager. Specifically, Neocortex targets the acceleration of AI-powered scientific discovery, and Voyager targets research that involves extremely large data sets using standard AI tools.
- In FY 2019, NSF put in place a five-year cooperative agreement for $5.0 million with the University

[5] www.nsf.gov/pubs/2020/nsf20101/nsf20101.jsp

of California-San Diego, University of California-Berkeley, and University of Washington for the establishment and operation of CloudBank, an entity that helps the academic community access and use public clouds for research and education by delivering a set of managed services designed to simplify access to public clouds. CloudBank is specifically enabling new research in AI by broadening the access and impact of cloud computing across many fields of research and education. Furthermore, through the Dear Colleague Letter 22-087 announced in May 2022, the process has been further streamlined for easier access to cloud resources for active NSF awardees.

- For FY 2024, NSF will continue to collaborate with other federal agencies to enable researcher access to deep, high-quality, and accurate federal training datasets for AI systems. For example, NSF is building upon a FY 2021 workshop that explored how researchers might collaborate with federal data stewards to bring the latest security- and privacy-enhancing techniques to bear on unlocking access to federal data sets, while adhering to applicable federal statutes, rules, and regulations. For example, in FY 2023, NSF is continuing the Privacy-Enhancing Technologies (PETs) Prize Challenges in collaboration with OSTP, NIST, and the Government of the United Kingdom, to mature PETs toward the point of demonstrating their viability in the context of specific use cases,

BIOTECHNOLOGY

Biotechnology Funding[1]

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$118.00	$122.75	$25.25	-	$148.00	$176.88
CISE	9.65	6.92	-	-	6.92	6.92
EDU	9.37	9.00	-	-	9.00	10.00
ENG	92.00	92.00	-	-	92.00	106.50
GEO Programs	10.00	10.00	-	-	10.00	10.00
GEO: OPP	1.60	1.60	-	-	1.60	2.00
MPS	75.63	62.20	-	-	62.20	62.20
SBE	1.68	1.50	-	-	1.50	1.50
TIP	30.00	35.31	17.27	16.48	69.06	93.05
IA	22.52	1.00	-	-	1.00	1.00
Total	**$370.45**	**$342.28**	**$42.52**	**$16.48**	**$401.28**	**$470.05**

[1] Funding displayed may have overlap with other topics and programs.

Overview

Since the first genetic engineering experiments over 50 years ago, the U.S. has become a world leader in biotechnology, with resulting biotechnological products contributing over $900 billion in economic activity, approximately 5 percent of the U.S. GDP, in recent years[1]. As a field, biotechnology comprises the data, tools, research infrastructure, workforce capacity, and innovations that enable the discovery, utilization, and reprogramming of living organisms, their constituent components, and their biologically related processes. Advances in biotechnology areas include genome sequencing, editing, and synthesis; synthetic and engineered biology; chemical biology and chemical genetics; imaging and biosensing; and computational methods, including artificial intelligence and biomolecule structure prediction. Across these areas, multi-disciplinary, bio-related approaches from engineering, mathematics, physical sciences, social and behavioral sciences, and computational sciences are spurring rapid development in biotechnology capabilities that drive innovation for the U.S. bioeconomy. These capabilities also provide solutions to societal challenges, such as climate change and infectious disease, and provide the foundational and use-inspired research that will lead to the creation of goods and services that contribute to the agriculture, health, security, manufacturing, energy, and environmental sectors of the nation.

NSF has long supported the breadth of fundamental research that catalyzes the development of biotechnology. Current investments from programs in almost every directorate include research and infrastructure across scales--from the molecular, to the organism and ecosystem--encompassing

[1] Hodgson, A., Alper, J., Maxon, M.E. 2022. The U.S. Bioeconomy: Charting a Course for a Resilient and Competitive Future. New York, New York: Schmidt Futures. https://doi.org/10.55879/d2hrs7zwc.

studies from foundational to use-inspired, carried out by individual investigators, collaborative teams, and multi-institutional centers. NSF also invests in educational programs to prepare and enable a workforce to support U.S. needs in biotechnology, and NSF funds research on the ethical, social, legal, economic, and environmental consequences of synthetic biology and other biotechnologies that contribute to public understanding and socially responsible use. These investments enable biotechnology innovations that not only address societal problems, such as climate change, food security, and clean energy, but also promote development of a robust supply chain of biologically derived materials needed to ensure U.S. resilience to global interruptions. Biotechnology promises to enable new modes of computation, including for information storage, retrieval, and processing; foods and feedstocks that will provide raw materials for new bioindustries; new organs and organisms engineered for multiple purposes; technologies capable of sensing emerging infectious agents; self-healing materials for sustainable infrastructure; and other heretofore unimagined products, processes and technologies inspired by, or developed with, living systems. Biotechnology advances will enable novel predictive tools and platform technologies to empower the U.S. to react rapidly to new and emerging biological threats, to address economic and societal challenges, and to respond with solutions for unanticipated problems.

NSF has responded to many reports and policy papers—including from the Office of Science and Technology Policy (OSTP)[2], the National Academies of Science, Engineering and Mathematics[3], the Government Accountability Office[4], the Bioeconomy Research and Development Initiative included in the CHIPS and Science Act of 2022[5], and Executive Order 14081, Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe and Secure American Bioeconomy[6]—to lead and coordinate interagency activities to promote synthetic and engineering biology, to develop next-generation tools to advance biotechnology, and to develop bold goals and research and development needs necessary to advance all sectors of the bioeconomy. NSF investments in FY 2022 and FY 2023 aimed at biotechnology innovation included programs for: Accelerating Innovations in Biomanufacturing Approaches through Collaboration between NSF and the DOE Bioenergy Technologies Office-funded Agile Biofoundry; Building Synthetic Microbial Communities for Biology, Mitigating Climate Change, Sustainability, and Biotechnology, Semiconductor Synthetic Biology Circuits for Communication and Information Storage; EFRI: Engineering Living Systems; EFRI: Brain-inspired Dynamics for Engineering Energy-Efficient Circuits and Artificial Intelligence; and new tracks on Sustainable Materials for Global Challenges and Food and Nutrition Security in the FY 2022 Convergence Accelerator solicitation. These programs build on programs initiated in FY 2021, e.g., Designing Synthetic Cells Beyond the Bounds of Evolution; Sentinel Cells for Surveillance and Response to Emergent Infectious Diseases; and Molecular Foundations for Biotechnology, and prior-year investments, e.g., Enabling Discovery Through Genomics; Future Manufacturing; Materials Innovation Platforms; Plant Synthetic Biology; and Reproducible Cells and Organoids via Directed-Differentiation Encoding. They also build on investments at the intersection of biotechnology and artificial intelligence and quantum sciences through the National Artificial Intelligence Research

[2]https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf

[3]www.nationalacademies.org/our-work/safeguarding-the-bioeconomy-finding-strategies-for-understanding-evaluating-and-protecting-the-bioeconomy-while-sustaining-innovation-and-growth

[4]www.gao.gov/products/gao-18-656

[5]www.govinfo.gov/link/plaw/117/public/167?link-type=pdf&.pdf

[6]www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy/

Institutes and Quantum Leap Challenge Institutes programs. Together, these new investments complement core programs in research, infrastructure, workforce development, and translation that advance U.S. competitiveness and leadership in biotechnology and the bioeconomy.

Goals

1. *Fundamental Research:* Support foundational and use-inspired research in science and engineering that will fuel innovations in biotechnology.
2. *Computing and Physical Infrastructure:* Develop the computing and physical infrastructure necessary to generate fundamental knowledge and advance accompanying biotechnology.
3. *Proof-of-Concept Advances:* Deliver proof-of-concept processes, devices, bio-based robots (biobots), applications, tools, and systems that enable the translation of fundamental advances for scientific and societal benefit.
4. *Education and Workforce Development:* Empower the full spectrum of U.S. talent to build the capacity to achieve the above goals and to generate the biotechnology-literate workers who will implement the results of these breakthroughs.

FY 2024 Investments

Fundamental Research

NSF will continue its support in the discovery of foundational biological principles and the development of biotechnologies and other tools that permit measurement and use-inspired manipulation and design of living systems and their components. New interdisciplinary partnerships across the agency will motivate bio-inspired design and stimulate use-inspired solutions, including through programs like Molecular Foundations of Biotechnology.

Computing and Physical Infrastructure

NSF will continue to invest in bioinformatics, computational biology, and artificial intelligence to support biotechnology. New synthesis centers in molecular and cellular biosciences and organismal biology will enable data synthesis and reuse for biological understanding and biotechnology design. To democratize access to essential research resources, NSF will establish a new Biofoundry program to support a network of center scale facilities with the express mission of developing new tools to advance biotechnology at multiple scales—molecular to organismal and ecosystem scale—and including multiple scientific foci, e.g., neurotechnology, artificial organs, bio-inspired materials, and bio-electronic devices. A seminal focus of the Biofoundry program will be to provide equitable access to enabling infrastructure, thereby building infrastructure capacity in institutions and geographic regions not currently well supported by NSF and ensuring that the necessary tools and capabilities for accelerating biotechnology research and development are broadly available to all.

Proof-of-Concept Development

Sustained support for synthetic and engineering biology as a pillar of biotechnology will accelerate the design-build-test-learn cycle and leverage bio-inspired design to develop bio-machines, biobots, and biomanufacturing technologies to address many of today's challenges. Biofoundries are an essential element in this cycle of proof-of-concept development. By providing broad, equitable access to infrastructure, the Biofoundry program will attract partnerships and drive economic acceleration, both in biotechnology and in linked areas of research and economic sectors. For example, biotechnology, robotics, AI, and semiconductor technology might leverage advances in synthetic and

engineering biology to build new storage media and devices that can take advantage of the high information storage capabilities of biological polymers. Advances in neuro- and nanotechnology could enable development of neuro-restorative devices that sense, respond, and learn. Synthetic microorganisms could serve as factories to provide new forms of clean energy and help mitigate impacts of changing climate. Plant biotechnology, aided by high-throughput transformation and phenotyping, could address food security and support advances in precision agriculture through production of crops better adapted to extreme environments or resilient to environmental change. New investments in regional innovation and Future Manufacturing will expand participation within the bioeconomy and accelerate the translation of biotechnology to solve societal problems. Partnerships, such as the pilot with NobleReach Emerge and those with other NSF Lab-to-Market programs such as the NSF Innovation Corps program, as well as new translational lineages such as the Pathways to Enable Open-Source Ecosystems program, will help accelerate the translation of all areas of biotechnology discovery and innovation into market products.

Education and Workforce Development

To prepare a diverse biotechnological workforce, NSF will invest through programs such as the Advanced Technological Education program at two-year institutions. Sites and supplements for Research Experiences for Undergraduates and Research Experiences for Teachers and supplements to support Non-Academic Research Internships for Graduate Students provide additional opportunities for training. The NSF Research Traineeship Program prepares graduate students to conduct research in convergent areas and acquire skills that allow them to succeed in diverse employment settings. NSF will also support training at the postdoctoral and early-career level through fellowships and participation in the NSF Entrepreneurial Fellows and Experiential Learning for Emerging and Novel Technologies programs, to enable scientists and engineers to further the societal benefits of their work. Through the Biofoundry network, NSF will support education and training that engages the broader STEM workforce in discovery and advanced biological and related technologies that can advance the U.S. bioeconomy and ensure national security.

MICROELECTRONICS AND SEMICONDUCTORS

Microelectronics and Semiconductors Funding[1]

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$3.00	-	-	-	-	-
CISE	41.00	40.00	-	-	40.00	40.00
EDU	-	-	-	-	-	6.00
ENG	43.00	43.00	-	-	43.00	63.00
MPS	50.96	31.00	-	-	31.00	33.00
TIP	15.00	25.69	12.56	11.99	50.24	67.68
Total	**$152.96**	**$139.69**	**$12.56**	**$11.99**	**$164.24**	**$209.68**

[1] Funding displayed may have overlap with other topics and programs.

Overview

Without semiconductors, the world would be a very different place; we would not have cellphones, personal computers, electronically controlled cars, appliances, or many other technologies we rely upon every day. They are omnipresent in transportation, communications, healthcare, manufacturing, and information technology, among other industries. Yet, U.S.-led innovations in semiconductors and microelectronics have slowed in recent decades, and the Nation is now facing historically unprecedented global competition.

Transistors, the building blocks of today's microelectronics, are approaching fundamental down-scaling limits in both size and energy efficiency. Additionally, current transistor technologies require a significant investment of scarce natural resources to produce and are energy inefficient when used. Another important consideration is safety and security of microelectronics throughout the lifecycle. Microelectronics and semiconductors warrant strategic investment to ensure continued U.S. leadership in this foundational technology, which will also facilitate leadership in many other technology areas that underlie major sectors of the economy and critical aspects of national security. Investments in sustainable microelectronics—including holistic manufacturing processes that use environmentally-benign materials, encompass the entire manufacturing lifecycle, and account for energy efficiency, health and environmental impact, and cost effectiveness—are critical to the existential challenge of our generation: climate change.

The overarching objective of NSF's investment in Microelectronics and Semiconductors is to develop new paradigms in semiconductor capabilities. Ongoing activities and new, complementary opportunities will leverage and create advances in materials, devices, circuits, architectures, and related software and applications. Advances in microelectronics and semiconductors in recent years continue to be made through longstanding NSF programs, including Electronics, Photonics and Magnetic Devices; Communications, Circuits, and Sensing-Systems; Semiconductor Synthetic Biology; Foundations of Emerging Technologies; Software and Hardware Foundations; Principles and Practice

of Scalable Systems; Secure and Trustworthy Cyberspace; Advanced Manufacturing; Materials Research programs, including the cross-cutting Designing Materials to Revolutionize and Engineer our Future program; as well as Science and Technology Centers; Engineering Research Centers; and Industry-University Cooperative Research Centers. The new Designing for Environmental Sustainability in Computing program addresses environmental sustainability of computing through its entire lifecycle from design and manufacturing, through deployment into operation, and finally into reuse, recycling, and disposal. NSF programs for innovation and translation, including the NSF Partnerships for Innovation, NSF Innovation Corps (I-Corps™), and the Small Business Innovation Research and Small Business Technology Transfer programs, have enabled new knowledge and designs to make their way into the market and society.

NSF's investments aim to demonstrate sustainable new semiconductors and microelectronic devices capable of overcoming the looming natural limits of current technologies and architectures. These investments will also enable the training of a critically needed U.S. workforce capable of adapting and advancing these technologies for a broad range of societal needs. This approach to NSF's investment in Microelectronics and Semiconductors will help overcome scientific barriers in essential technologies such as: advanced computing; artificial intelligence; distributed mobile processing platforms; internet of things; quantum communication, computing, and sensing; advanced communications; advanced manufacturing; and biological-semiconductor interfaces.

Goals

- *Support research and development of new, secure, high-performance devices and systems* supported by novel and sustainable materials that offer improved security and energy-efficient functionality.
- *Investigate and implement methods and techniques to integrate new classes of devices into microelectronic circuits for diverse platforms.* Microelectronic devices are fabricated by integrating transistors with numerous other components that work with different physical principles. The need to bring various components—electrical, optical, magnetic, and quantum—into a microelectronic circuit necessitates the investigation of new co-design, packaging, and testing methodologies.
- *Create a semiconductor and microelectronics R&D ecosystem.* This ecosystem will enable researchers and trainees to fabricate novel transistors and devices and to integrate component technologies into systems using heterogeneous integration techniques. The ecosystem will connect user facilities to fabricate devices in the laboratory, advanced methods for semiconductor manufacturing, and partnerships with industry to translate laboratory-generated ideas into foundry-fabricated prototypes.
- *Grow a diverse workforce* across the U.S. and provide experiential learning and training opportunities in partnership with industry to support the ecosystem, from researchers to technicians, theorists to experimentalists, and entrepreneurs to practitioners.

FY 2024 Investments

<u>Research in Foundational Principles</u>
Ongoing and new opportunities in foundational research, from individual-investigator projects to efforts comprising large multidisciplinary teams, will create new classes of novel, secure, sustainable, high-performance semiconductors for microelectronic devices.

Methods for Integrating Devices into Diverse Platforms

NSF will invest in existing and new opportunities, including research infrastructure and use-inspired research, to investigate and implement new methods for device integration and novel architectures.

Microelectronics Ecosystem

NSF will continue to invest in advanced manufacturing research, lab-to-fab opportunities, and research infrastructure, such as the NSF Quantum Foundries and NNCI, to translate benchtop microelectronics and semiconductors research to fabrication and manufacturing.

Workforce Development

To prepare a diverse microelectronics and semiconductors workforce across the U.S., NSF invests in STEM education at all levels and across settings. Relevant NSF programs include Advanced Technological Education, NSF Research Traineeship, Faculty Early Career Development, Research Experiences for Undergraduates, Research Experiences for Teachers, as well as semiconductor and microelectronics education in research projects. NSF support for Non-Academic Research Internships for Graduate Students and I-Corps™ provides students with industrial and entrepreneurship experience.

One example of an activity funded in FY 2024 is the expansion of the Future of Semiconductors (FuSe) program, which supports both research and workforce development. FuSe will invest in new materials, materials processing and characterization, fabrication, devices and systems, and computing, sensing, and communication systems answering both near-term supply chain concerns and longer-term Post-Moore's Law challenges. FuSe will invest in research opportunities in semiconductor-related areas including new materials, fabrication and manufacturing, electronics, and computer systems. FuSe will also consider research infrastructure needs in this domain, particularly improving semiconductor fabrication foundry access for NSF-funded researchers, and how potential partnerships with industry may facilitate such access.

QUANTUM INFORMATION SCIENCE (QIS)

Quantum Information Science Funding[1]
(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$3.28	$3.28	-	-	$3.28	$3.28
CISE	25.03	20.70	-	-	20.70	24.74
EDU	14.08	4.00	-	-	4.00	5.00
ENG	31.17	29.50	-	-	29.50	32.89
MPS	229.87	179.00	-	-	179.00	214.00
TIP	25.00	19.65	9.60	9.18	38.43	51.76
OISE	-	1.00	-	-	1.00	1.00
IA	19.36	-	-	-	-	-
Total	**$347.79**	**$257.13**	**$9.60**	**$9.18**	**$275.91**	**$332.67**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actual may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Overview

QIS research will advance fundamental understanding of uniquely quantum phenomena that can be harnessed to promote information processing, transmission, and measurement in ways that classical approaches do less efficiently, or not at all. Current and future QIS applications differ from prior applications of quantum mechanics, such as lasers, transistors, and magnetic resonance imaging, by using distinct quantum phenomena—superposition and entanglement—that do not have classical counterparts. The development of these new applications will form the basis of one of the major technological revolutions of the 21st century. Building upon more than three decades of exploratory discovery, NSF investment in QIS will help propel the Nation forward as a leading developer of quantum technology. These investments are a key component of the National Quantum Initiative (NQI) and address the Administration's focus on helping build emerging industries.

NSF's QIS investments build upon the agency's long-standing and continuing foundational investments in QIS as well as more recent, interdisciplinary investments in centers and small teams and targeted workforce development efforts. NSF's QIS Investments are influenced by the analyses and recommendations included in a series of NSTC reports. Among these are: *Quantum Frontiers Report*[1]*, A Coordinated Approach to Quantum Networking Research*[2]*, The Role of International Talent in Quantum Information Science*[3]*,* the *QIST Workforce Development National Strategic Plan*[4]*,* and *Bringing*

[1] www.quantum.gov/wp-content/uploads/2020/10/QuantumFrontiers.pdf
[2] www.quantum.gov/wp-content/uploads/2021/01/A-Coordinated-Approach-to-Quantum-Networking.pdf
[3] www.quantum.gov/wp-content/uploads/2021/10/2021_NSTC_ESIX_INTL_TALENT_QIS.pdf
[4] www.quantum.gov/wp-content/uploads/2022/02/QIST-Natl-Workforce-Plan.pdf

Quantum Sensors to Fruition.[5] Investments will target all major areas of quantum computing, communications, sensing, networking, and simulation. Special attention as to how these areas connect with each other will accelerate development in all of them and lead to advances in quantum computers, quantum communications networks, quantum sensors that enhance resolution and detection capabilities significantly, and networks that can connect components of quantum systems without loss of fidelity. Collaboration with fields beyond the core of QIS will identify end users of new quantum technologies and help establish the market for new tools and applications, from security to biomedical. Ultimately, this work will allow quantum technology to become established on a sound footing and play a recognizable role in advancing the U.S. economy.

Consistent with and crucial to its mission, NSF will form partnerships with other federal agencies, industry, private foundations, national laboratories, and existing centers to leverage NSF's investments in QIS research and education. In addition, international cooperation with like-minded countries is critical to ensure that discoveries, and their resulting technologies, provide for economic growth and national security. NSF will continue to provide funding opportunities for QIS researchers to enable researchers' access to industry-built quantum-computing platforms and to support international collaboration efforts. In FY 2024, NSF will continue to support the Expand QISE program begun in FY 2022, which focused on enhancing the participation of academic institutions not currently participating in the national QISE initiative and promoting the inclusion of members of groups currently underrepresented in the field. NSF will support educational efforts in QIS across all levels including higher educational and opportunities for K-12 teachers and students.

Goals

- Answer key science and engineering questions to facilitate the fundamental understanding of quantum phenomena and systems, as well as the translation of that fundamental knowledge into technological applications.
- Deliver proof-of-concept devices, applications, tools, or systems with a demonstrable quantum advantage over their classical counterparts that will form the basis of a revolutionary 21st-century technology.
- Empower the full spectrum of talent to which NSF has access to build needed capacity and generate the quantum-literate workforce that will implement the results of these breakthroughs, with a special focus on reaching out to MSI's and expanding the QIS workforce in ways that will enhance the diversity of that workforce through the inclusion of members of groups heretofore underrepresented in the endeavor.

FY 2024 Investments

In FY 2024, NSF will call for proposals to begin the design phase of the National Quantum Virtual Laboratory (NQVL), which was initiated with a pilot phase in FY 2023. The NQVL is a community-wide infrastructure platform designed to facilitate the translation from basic science and engineering to the resultant technology, while at the same time emphasizing and advancing its scientific and technical value. The NQVL aims to develop and utilize use-inspired and application-oriented quantum technologies within the context of the academic environment. In the process, NQVL researchers will explore quantum frontiers, foster QISE workforce education and training, engage in outreach activities

[5] www.quantum.gov/wp-content/uploads/2022/03/BringingQuantumSensorstoFruition.pdf

at all levels, and promote broadening participation, diversity, equity, and inclusion in QISE. Concurrently NSF will continue its investment in the Quantum Leap Challenge Institutes (QLCI), the Transformational Advances in Quantum Systems (TAQS) series of small-team awards, the Expand QISE efforts to enhance capacity in the QIS enterprise, and foundational core investments in individual investigator programs and disciplinary centers.

Investments by Program Component Area

QIS Funding by Program Component Area

(Dollars in Millions)

			Disaster Relief Supplemental			
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request
Foundational Quantum Info. Science Advances	$185.10	$122.67	$0.60	$0.57	$123.84	$138.45
Quantum Computing	41.85	39.71	2.25	2.15	44.11	55.41
Quantum Networks and Communications	35.35	30.25	2.17	2.08	34.50	41.65
Quantum Sensing and Metrology	29.25	28.09	0.73	0.70	29.52	37.42
Future Applications	39.06	28.14	3.16	3.02	34.32	46.45
Risk Mitigation	4.52	3.63	0.38	0.36	4.37	6.60
Supporting Technology	12.65	4.64	0.31	0.30	5.25	6.69
Total	**$347.79**	**$257.13**	**$9.60**	**$9.18**	**$275.91**	**$332.67**

[1] FY 2022 Actual may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Foundational Quantum Information Science Advances

Notwithstanding the significant progress that has been made in QIS over the past five years, as a technology, the field is still in its infancy. Many questions that lie at the heart of the field remain to be addressed and answered. At the same time, new discoveries enable new directions that open new as-yet-unexplored opportunities. NSF will maintain significant investment in the underlying disciplinary programs and will consider supporting new collaborative center-level activities in all areas that have the potential to enable these scientific breakthroughs.

Quantum Computing

Much progress has been made in superconducting and ion-trap quantum computing architectures, and NSF continues to lead the way through investments in approaches to scale these by at least a factor of ten or more. However, there is no single platform that has emerged as the leading contender, and multiple architectures might simultaneously co-exist to support distinct types of quantum computations enabled by each. NSF will continue exploring alternative quantum computing architectures that could emerge as viable options in the future, as well as the basic underpinnings and limits of quantum computing as defined by the underlying physical processes and architectures. At the same time, in collaboration with industry, NSF will continue to support researcher access to quantum systems and platforms to experiment in specific domains.

Quantum Networks and Communications

While the exact implementation of quantum processing nodes and qubits is still the topic of research and debate, the information between the quantum processing nodes will most likely be carried by photons. Therefore, interfacing different types of qubits with photons is critical for the realization of scalable distributed quantum computational systems as well as for coherent connections between quantum platforms dedicated to computing, communication, and/or sensing. NSF will support cross-disciplinary teams of engineers, mathematicians, computer scientists, and physical scientists to develop basic research results that enable emerging quantum computing systems to interface with each other as well as with existing traditional computing systems.

Quantum Sensing and Metrology

Quantum sensors offer the most recognized near-term end-user applications of second-generation quantum technologies. Potential users cover the scientific spectrum, from precision measurements in physics to high-resolution imaging in biology to seismology in earth sciences. Exploiting the potential offered by quantum-based sensors relies on establishing close connections between the builders and the users. NSF would achieve this through a series of community-building activities such as Research Coordination Networks and "Dear Colleague" letters emphasizing areas of mutual interest.

Future Applications

In FY 2021, NSF initiated an investment in a QIS Convergence Accelerator track designed to promote the more rapid translation of basic quantum knowledge into the private sector. This investment will continue in FY 2022, together with on-going programs that support connections and collaborations with industry.

Risk Mitigation

Concomitant with investments that promote the development of new quantum-based computational and communications tool, NSF will support efforts to counter the risks that emerge with these new technologies.

Supporting Technology

Building the QIS technology portfolio will require the simultaneous development of classical tools that are needed to perform research and develop prototypes. Working through existing disciplinary programs, NSF will support researchers who are developing tools and algorithms that are especially adapted to quantum applications.

BUILD A RESILIENT PLANET

Description and Rationale

Resilience is the watchword as the U.S. and the world increasingly feel the impacts of a changing climate and the growing need for clean, reliable, sustainable energy. Without the resilience to withstand and recover quickly from these impacts, we are at the mercy of heat waves, droughts, floods, wildfires, rising oceans, and other extreme events, as well as power disruptions, economic instability, food and water insecurity, and the deleterious effects on human health. NSF's Build a Resilient Planet initiative will take on the multifaceted challenges of:

- Predicting the response of Earth's systems to a changing climate and how natural and built systems respond to increased environmental variability;
- Innovating clean energy technologies, and associated infrastructure that can adapt to a changing planet;
- Improving climate adaptation and resilience to maximize resource utilization and sustainability within the food-energy-water system;
- Developing nature-based solutions to combat climate change; and
- Enhancing national efforts in greenhouse gas (GHG) measurement, monitoring, and verification of emissions and GHG removal from the atmosphere.

The magnitude of these challenges demands a whole-of-NSF approach to engage scientists and engineers through convergent research that addresses societal needs and integrates research and education. NSF will invest strategically in emerging areas to ensure U.S. leadership for an economically strong, nationally secure, sustainable, and equitable future. NSF will also leverage and enhance investments in essential research infrastructure needed to drive the discoveries that will build a more resilient planet.

Accelerating climate research and developing solutions to reduce the impacts of climate change, inventing energy systems of the future and developing solutions to the interconnected challenges of resilience requires bold thinking, convergent approaches, and an overarching commitment to environmental equity, justice, and workforce development and education. NSF will take action to advance knowledge, empower and engage communities, grow a capable and diverse scientific workforce, and generate innovative technological solutions; this includes learning with and from likeminded international partners at all scales. Through strategic investments, NSF will implement President Biden's promise to take aggressive action to tackle climate change while addressing the economic and national security threats posed by the climate crisis. Investments proposed are consistent with the U.S. Global Change Research Program (USGRP) and Clean Energy Technology (CET) crosscuts. Furthermore, investments in NSF's major facilities that target study of Earth's biosphere, atmosphere, and oceans, contribute to USGCRP, and will be a core element of this activity.

Transformational action in this decade is essential to enabling a resilient future. Increases in GHG, largely because of the combustion of fossil fuels, have altered the Earth's atmosphere, leading to warming temperatures and rapidly changing biological and physical environments. Because these climate-driven changes influence processes at a range of spatial and temporal scales across terrestrial, atmospheric, freshwater, and ocean systems, it is imperative that a "whole Earth" approach is taken to understand the impacts.

Climate change impacts the health, prosperity and welfare of people and communities, posing a major economic and security threat to the Nation. The changing climate often makes extreme events, such as hurricanes, wildfires, and drought, more severe and frequent. Such events also result in damaging effects on water supplies, air quality, housing, and critical infrastructure such as power, communication, and transportation. Oftentimes the impacts of extreme events fall disproportionately on disadvantaged communities. NSF's approach to resilience explicitly includes the concept of environmental justice, reaching and involving the most at-risk or vulnerable communities to play a lead role in their resilient future through community-driven engagement as agenda-setters and active participants in resilience research. Disadvantaged and underserved communities will directly build, and benefit from, Build a Resilient Planet.

The grand challenges of enabling a carbon-neutral energy system and understanding, forecasting, mitigating, and adapting to the Earth's changing climate at global to local scales can only be met through scientific, engineering, and technological advances. To achieve a carbon-neutral, equitable, and sustainable economy, clean energy must increasingly dominate energy sources. Critical technological advances are needed to maximize access and utilization of renewable energy, enable grid security and storage, and electrify manufacturing, transportation, and chemical processing. To advance climate adaptation and resilience, new technologies are needed with equitable access to create well-being and health across the U.S. NSF will invest in research and engineering that integrate and translate knowledge regarding climate change risks to health, national security, and the economy and translate this understanding into decision-making tools to enable greater predictability of impacts and resilience for the U.S. and ultimately the world.

NSF's investments in Build a Resilient Planet will advance the priorities of the CHIPS and Science Act. They will improve our understanding of climate systems and related environmental and human interactions, water quality and food-energy-water systems, and natural hazards and community resilience, including social and behavior dimensions. Build a Resilient Planet will advance sustainable chemistry, the provision of critical minerals, engineering biology, and biomanufacturing to enable economic growth that protects people and the planet. NSF investments will lead to innovative data-driven solutions for climate adaptation and mitigation; new technologies and strategies for clean, abundant energy, water, and food, such as precision agriculture; and rural and urban infrastructure that is resilient to wildfires, droughts, extreme storms, and other natural and anthropogenic disasters. Innovations in high-performance computing, semiconductors, and advanced computer hardware and software are essential to enable computational approaches to modeling, simulation, visualization, analysis, and prediction at the speed and scale needed for climate and clean energy systems. While these computing-based technologies have the potential to be transformative, it is also important that they should be designed to be sustainable with respect to energy consumption, depletion of rare earth elements, creation of toxic byproducts, and other sustainability metrics. To be a global leader in the research needed to build a resilient planet, NSF will rely heavily on current and proposed research infrastructure investments. Furthermore, NSF's Build a Resilient Planet portfolio will grow a diverse workforce across the Nation that will continue building knowledge and sustainable U.S. infrastructure and industry.

Goals of Investment

- To catalyze convergent research at speed and scale with an integrated systems approach that focuses on the causes and predictable impacts of climate change while also developing paradigm-shifting clean energy technologies and infrastructure systems; other non-energy related technologies aimed to improve sustainability and reduce environmental impacts; sustainable food and water sources and waste management; and adaptation and mitigation strategies. These efforts will be tailored to a local/regional scale with the ability to scale for global impact.
- To integrate foundational and use-inspired science and engineering research with translational approaches to clean energy and climate resilience, adaptation, and mitigation, with attention to predictive modeling and experimental testing.
- To engage effectively and respectfully with communities through the incorporation of local, traditional, and indigenous knowledge in research programs co-designed with impacted stakeholders.
- To enhance research investments in resilience through support for an integrated, mission-oriented approach beyond approaches traditional for NSF with the goal of rapidly stimulating research for deployment of solutions within the coming decade towards a sustainable Earth. These new investments will build on existing climate- and energy-related activities supported through the Foundation's research portfolio.
- To develop and enhance research infrastructure investments that are essential to advancing science and engineering that will build a more resilient Earth system.
- To develop systems-thinking capacity in the training of a skilled, globally competitive, and diverse generation of scientists and engineers while actively engaging communities and the public.
- To democratize resilience and the ability for all communities to engage in climate resilience research regardless of socio-economic or geographical circumstances.
- To establish integrated and equitable public and private partnerships among local communities, researchers, educators, communicators, industry, international partners, and policy makers to advance knowledge, empower communities, and catalyze resilience solutions towards a sustainable earth.

Potential for Impact, Urgency, and Readiness

The Nation is poised to embark on the urgent mission of building a resilient planet, as highlighted in numerous recent reports:

- The Intergovernmental Panel on Climate Change[1] found that the world is today facing unprecedented challenges because of climate change, with impacts more severe than expected.
- The recent Engineering Research Visioning Alliance report "The Role of Engineering to Address Climate Change"[2] focuses on investments in critical materials, energy storage and transmission, resilient and energy-efficient infrastructure, GHG capture and elimination technologies, ecosystem sensor and sensing applications, and exploiting artificial intelligence modelling in forecasting and trend analyses.
- As envisioned in the National Academies of Sciences, Engineering, and Medicine (The National Academies) report on "Next-Generation Earth Systems Science at the NSF,"[3] a systems-thinking

[1] https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf
[2] www.ervacommunity.org/visioning-report/visioning-event-report/
[3] https://doi.org/10.17226/26042

approach is needed, identifying the mechanisms and opportunities that interrelate understanding of the climate system, clean energy technologies, and society in holistic solutions to the growing climate and clean energy crisis.
- As recommended in the National Academies report on Accelerating Decarbonization of the U.S. Energy System,[4] bold and decisive action is urgently required to address the need for clean energy. New resources are necessary to both initiate and accelerate new discovery and insights as well as the translation of research results to technological solutions.

NSF's support of all fields of science and engineering make it uniquely capable of advancing the integrated, interdisciplinary research needed to enable a resilient nation and planet. NSF investments in cyberinfrastructure, computing, communications, and information systems will support the interconnected areas of the Resilient Planet portfolio. Likewise, NSF investments in education, diversity and inclusion will prepare a future workforce that understands the complex interdependencies of changing Earth systems and the built environment and that can innovate clean energy and related green industries. These investments will ensure that the U.S. continues to be a global leader in the management, mitigation, and adaptation to climate change for an economically strong and secure future.

Impacts will be realized across several key areas:

<u>Advancing Climate Science</u>
Understanding climate change and the associated impacts on human and environmental systems is the central thrust to much of NSF's resilience research and is essential to identifying, developing, and ultimately implementing solutions to mitigate climate change impacts. One of the critical keys to the resilience puzzle is predicting tipping points; the point at which a series of small changes or incidents becomes significant enough to trigger a larger, more impactful change. Understanding and predicting tipping points reveals how changes in climate lead to drought, wildfire, thawing of permafrost, ice loss and sea-level rise, coastal flooding, and severe storms.

A scientific understanding of climate and the ability to predict impacts of climate change are not sufficient to catalyze resilience. Research results will be translated into actionable information allowing policy makers to understand regional and local threats and enable the development of implementable mitigation strategies. NSF brings tremendous energy and focus to the challenge of resilience and through coordination with USGCRP, as NSF's efforts are leveraged and built on by other government stakeholders enabling a whole-of-government effort to build a resilient future.

<u>Innovation in Clean Energy Technology and Infrastructure</u>
The discovery, development, and deployment of clean energy solutions remains a primary mechanism to attenuate the impacts of climate change and provide a path to thrive in a world that is increasingly reliant on dependable, cost-effective, on-demand energy. NSF will invest in foundational research, translation, and collaboration for a new generation of sustainable energy technologies that speed the U.S. on our race to net zero emissions, benefit human health and the environment, and serve society equitably and without disproportional impacts.

NSF's clean energy investment will focus on enabling and advancing the transformation of energy

[4] https://nap.nationalacademies.org/catalog/25932/accelerating-decarbonization-of-the-us-energy-system

systems for the future, including new energy sources, hydrogen at scale, energy-efficient technologies, energy storage and transmission, and secure and sustainable energy systems. These investments will advance fundamental physics, chemistry and next-generation materials science research pertaining to energy, as well as research related to social, cultural, and individual acceptance of energy system transitions. Themes will include energy security and reliability; interconnection of built infrastructure, energy infrastructure, and cyberinfrastructure for overall resilience and efficiency; biotechnology, eco-manufacturing, industrial efficiency technologies, and the circular economy (including critical minerals and materials); modeling and tools; social and behavioral aspects; and development of a diverse workforce.

Advances in theoretical, computational, and experimental research on topics such as plasma science, thermoelectrics, and superconductor research provide new opportunities to reconceptualize clean energy systems globally. Advances in fundamental materials and device research are also needed, which will lead to deployment of superconducting-based technology at ambient conditions would most directly influence and reduce waste in energy transport. Advancing the fundamental understanding and utilization of superconductivity as well as other phenomena such as multiferroicity, piezoelectricity, and thermoelectricity positions the U.S. to redefine other industrial sectors, such as semiconductors, optoelectronics, wireless information transmission, and smart health. Cross-cutting contributions from artificial intelligence (AI), cloud, wireless networking, and other computational based technologies have already surfaced new advances in these important areas and expanded funding can accelerate these further. Similarly, advanced manufacturing of materials that can operate in extreme environments, such as non-equilibrium multi-component alloys, is needed for next generation energy systems.

NSF's clean energy approach will be further advanced by systems-oriented studies of clean energy generation and use. These include new smart wireless sensor-based technologies to enhance operation, storage, integration, and distribution of different types of clean energy. Likewise, large-scale data analytics and AI techniques will allow for more efficient monitoring, management, and maintenance of decentralized energy grids, especially in remote locations or hazardous conditions. NSF will also advance novel research that addresses the substantial environmental impacts that computing technologies have through their entire lifecycle from design and manufacturing to deployment and operation, and finally into reuse, recycling, and disposal.

Climate Change Adaptation and Resilience

Build a Resilient Planet will utilize a holistic approach that pulls together the interconnected systems of climate, biosphere, and the built environment, along with understanding of human behavioral, economic, and international dimensions, to predict change and inform and advance equitable adaptation, mitigation, and resilience strategies. Only by harnessing and integrating physical, biological, computing, and social sciences and engineering can we create truly resilient, sustainable systems. In a warming climate, multidisciplinary research is crucial for advancing our predictive understanding of the response of living and engineered systems at all temporal and spatial scales. It is also crucial for developing capabilities to mitigate negative environmental impacts through, for example, emissions capture and reuse, energy efficiency, extreme design for a changing climate, and alternative chemicals, materials, and manufacturing processes. Research on climate change mitigation and adaptation systems that includes environmental, educational, infrastructural, health, and community elements will create sustainable and resilient strategies to manage and engineer the changing world. In a virtuous cycle, some climate change mitigation and adaptation strategies may be

independent of or indirectly related to clean energy solutions while some clean energy research investments will yield new climate change mitigation and adaptation strategies.

Maximizing the use of resources and developing emission mitigation technologies is central to limiting the severity of negative impacts of climate change. Technologies beyond clean energy, such as emissions mitigation and environmental remediation technologies, could lead to a strengthened and sustainable infrastructure. NSF will invest in fundamental science and technologies that support a circular economy by mitigating GHG emissions; developing overall carbon-neutral or carbon-negative processes; improving product circularity and efficiency, including reclaiming precious resources and advancing precision agriculture; addressing emerging new contaminants, and developing new chemicals, materials, technologies, and processes that minimize the production or enhance remediation of waste to support clean water, air, and soil. NSF will invest in innovative, foundational, use-inspired, and translational research in several areas including electrochemistry, catalysis, fusion and plasmas, photochemistry, photonics, enhancements in efficiencies of chemical reactions, chemical separations, surface chemistry, and subsurface flow and transport by using innovative computational, data science and experimental approaches.

The role of high-performance computing, AI, and data sharing in advancing research on climate change, natural resource depletion, loss of biodiversity, extreme events, and sustainable energy is undeniable. Advances in computation, from smart sensors to cloud-based data aggregation and analytics, to high precision computational modeling, improves our understanding of environmental trends and play an intrinsic role in global efforts to understand, analyze, and mitigate the effects of climate change, moving society towards intelligent adaptations and greater resilience. However, the widespread, intensive use of computing technologies introduces sustainability challenges and motivates new approaches across the lifecycle of technology design, use, and decommission. To balance opportunities of advanced computation with computing's own GHG emissions, which are on par with mid-sized countries, NSF will support investments that treat GHG emissions and sustainability impacts as first-order metrics for computing design and use, along with broader research directions including discovery of new sustainable materials for manufacturing digital devices, seamless integration of renewable energy, and methods for safe recycling and reuse of e-waste.

Ensuring the success of these resilient solutions requires continuous engagement with stakeholders; this engagement will help ensure that research answers questions and designs solutions that are relevant at the local and regional scales and enhance decision making. Further, through interaction with stakeholders, NSF's investment will facilitate science-based risk communication, citizen science, and community-engaged research programs, enhancing the investment's overall impact. An added benefit of local and regional engagement is the direct conduit that is built to disadvantaged communities. Build a Resilient Planet will explicitly focus on developing proactive and accessible resilience and adaptation strategies for historically underserved and disadvantaged communities to co-create resilience solutions that are just, inclusive, and equitable. The effects of climate change, such as extreme natural hazards, exacerbate existing environmental and societal inequities and contribute to cumulative burdens on vulnerable communities; NSF's investments will advance economic and environmental justice, equity, and public health through reduced vulnerability to climate impacts. Research infrastructure will also be a core element in NSF's goal of expanding access to facilities for traditionally underserved groups and communities. This infrastructure will enable underserved STEM researchers to significantly contribute to helping their communities become more resilient. Research infrastructure will also be central to developing the next generation of researchers and engineers that

are essential for ensuring the U.S. continues to be a world leader in climate and clean energy research and to ensure a strong economy and secure nation.

Nature-based Climate Solutions

Build a Resilient Planet will include research to understand the effectiveness of nature-based climate solutions, including terrestrial, freshwater, coastal, and ocean ecosystems that provide carbon sequestration and storage and which can enhance ecosystem and human community resilience. Understanding how living systems respond and adapt to climate change can help us design and implement solutions that go beyond mere survival under adverse conditions to enable robust resilience in the face of continual change. Taking advantage of knowledge at multiple scales of biological organization—from molecules to genomes to cells to organisms to populations and ecosystems—as well as how biological systems interact in diverse environments provides a foundational basis to use the information to improve life on our warming planet. By sustaining and restoring valuable ecosystem services, research funded by NSF will create economic opportunities for farmers, ranchers, fishers, and foresters and will also contribute to improving national security. In addition, NSF investments in precision agriculture, biotechnology, food-energy-water systems, control of nitrogen and methane emissions from agriculture, and other research areas will mitigate climate change impacts and increase the sustainability of future U.S. agriculture.

Always present in NSF activities is the theme of investing in the next generation of researchers, scientists, and citizens. Build a Resilient Planet will strengthen the development of the workforce to design, implement, and manage effective nature-based solutions and hybrid options that integrate traditional and nature-based approaches.

GHG Monitoring, Measurement, and Verification

Measurement, monitoring, reporting, and verification of GHG emissions and removal is critical to understanding and enhancing the progress and effectiveness of local to global actions to address drivers of climate change. These strategies can serve as a foundation for assessing success of biotechnologies capable of using waste gases as substrates for sustainable synthesis of fuels and chemicals, thereby contributing to mitigation of the warming effects of such gases. Through Build a Resilient Planet, NSF will continue to develop sensors, imaging tools, and technologies for GHG detection, understanding of the impacts of proposed solutions, to develop new technologies for capturing, converting, and sequestering GHG, and to work with partner agencies to transition NSF-funded research tools and technologies to operational use by other agencies or industry.

Budget Justification

All NSF units are essential to the success of Build a Resilient Planet. Investments include ideas from researchers across the science and engineering spectrum to create broad new understanding and innovations that will increase energy resilience, enhance sustainability, mitigate climate change, and lead to other societal benefits. NSF's Build a Resilient Planet theme is being initiated in FY 2023 with investments in the National Discovery Cloud for Climate, Design for Environmental Sustainability in Computing, Future Manufacturing, Critical Aspects of Sustainability, and Global Centers.

FY 2024 will build on these and other efforts through key targeted investments, including:

- Fundamental and convergent research with increasing investments in themes such as life on a warming planet, extreme events and climate thresholds, computational climate science and

prediction, sustainable computing design, technologies for decarbonization, and co-production of knowledge. NSF will also initiate new activities in design for extreme environments.

- Cross-cutting interdisciplinary research will continue and expand to encourage creative and collaborative research in areas such as sustainable regional systems, and innovative solutions to climate change and sustainable chemistry to address critical aspects of sustainability (CAS).
- Research infrastructure essential to advancing research for enhancing resiliency will be a core focus of this activity. BIO will continue to invest in the National Ecological Observatory Network (NEON) by expanding the biorepository capacity. GEO will continue support for the National Center for Atmospheric Research (NCAR), the Academic Research Fleet (ARF), infrastructure and logistics to support access to the Arctic, Antarctic continent, and Southern Ocean, the seismic and geodetic services of the SAGE/GAGE facility, and continued development of the design for the Antarctic Research Vessel (ARV). CISE, through its Office of Advanced Cyberinfrastructure, will oversee continued implementation of the National Discovery Cloud for Climate.
- Centers and hubs for research, testing, coordination, and translation will be established to address complex challenges in adaptation and resilience, the bioeconomy, clean energy, wildfires and drought at the urban/rural interface, sustainable chemistry, connections with the environment and society, and other topics. Likewise, connectors will be funded to couple foundational advances across and within other large-scale NSF research and infrastructure investments into these new centers and hubs.
- Innovation and translation investments will continue to accelerate new research discoveries, technologies, and solutions into the market and society.
- Research infrastructure investments in more energy-efficient facilities, advanced computing, digital simulations, electric grid testbeds, *in situ* environmental observation technologies, and Natural Hazards Engineering Research Infrastructure (NHERI) will continue, and new opportunities for access to facilities and testbeds will begin. NSF's National Discovery Cloud for Climate as well as the National Artificial Intelligence Research Resource (NAIRR) are envisioned as shared computing and data infrastructure that democratizes access to advanced cyberinfrastructure and will serve to expand the geography of innovation by enabling researchers everywhere in our Nation to engage fully in and advance these topics.
- Education and workforce development investments will prepare diverse students across the country for climate and clean energy careers. Preparing a future workforce that understands the complex interdependencies of the climate, human, and other earth systems and that can innovate in clean energy and related green industries is critical for the U.S. Also important will be efforts to engage the public through informal learning on climate and clean energy topics. In FY 2024, NSF will start a special initiative to support Climate Equity Fellows. This program will train students and researchers in science important for addressing climate change and to be knowledgeable about the disparate impacts of climate change on disadvantaged or underserved communities and to integrate these perspectives into the design of their research projects.
- NSF's partnerships with other agencies and the private sector will help accelerate fundamental and translational research and prepare the future workforce to Build a Resilient Planet.

CLEAN ENERGY TECHNOLOGY

Clean Energy Technology Funding[1]

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$50.00	$55.00	-	-	$55.00	$74.50
CISE	29.28	39.50	-	-	39.50	39.50
ENG	150.00	163.00	30.00	-	193.00	229.75
MPS	123.08	123.83	-	-	123.83	123.57
OISE	17.05	7.50	-	-	7.50	12.50
OIA	0.14	-	-	-	-	-
TIP	49.20	39.95	13.12	12.52	65.59	70.69
Total	**$418.75**	**$428.78**	**$43.12**	**$12.52**	**$484.42**	**$550.51**

Overview

Energy is essential, and our future as a people and a Nation depends on our leadership in the transition to clean energy. That leadership depends on winning the research, innovation, and education race to transform the energy sector and ensuring the global competitiveness of our energy workforce. NSF will advance the clean energy future through investments in foundational research to transform energy systems and develop new energy industries; innovation and translation to move discoveries to the market and society; and education and workforce development, with a focus on preparing for the energy jobs of the future. Clean energy investments complement and align with NSF investments to advance climate change understanding, adaptation, and mitigation.

Energy production and use in the U.S. continues to grow, supporting our residential, commercial, and industrial sectors. The use of hydrogen, fusion, and renewable energy (such as solar, wind, geothermal, hydro, tidal and biomass) is enabled by new discoveries, new technologies and the translation of those discoveries and technologies to practical solutions (for example, energy conversion technologies like fuel cells, and energy distribution technologies like the smart grid). Increased energy-efficiency and energy-use management tools support the U.S. economy as industries and households transition to clean-energy solutions, while supporting increased energy demands associated with computing and communication systems. Advances in designing and producing chemicals and materials for clean energy and energy efficiency technologies, as well as electrification of the chemical industry and transportation sectors, are critical to the transition to a carbon neutral world, with reduced impacts of energy systems on the global climate. Advances in plasma science, thermoelectrics, catalysis, and semiconductors provide new opportunities for energy system transformations. Integration of advances in biotechnology and bio-inspired systems into energy research will propel discovery and applications that create new industries. Leveraging artificial intelligence and optimization across energy systems will shape the energy sector of the future. Advances in designing the next generation of computing systems will enable novel ways to not only dramatically increase energy efficiency but also incorporate clean energy technologies in the entire

computing lifecycle. Current and planned future NSF's investments across these research areas, from clean energy sources to clean energy uses (transportation, industry, cyberinfrastructure), will support U.S. leadership in the transition to clean energy.

NSF's clean energy investments span longstanding programs as well as focused solicitations. Research funding opportunities in clean energy enable partnerships of investigators in the economic and social sciences, education research, biological sciences, physical sciences, computing and information sciences, and engineering disciplines to build fundamental knowledge and overcome technological barriers. NSF continues to make long-term investments in multidisciplinary research centers through the Centers for Chemical Innovation, Expeditions in Computing, Engineering Research Centers, and Industry-University Cooperative Research Centers programs. NSF also supports research infrastructure such as the Grid-Connected Testing Infrastructure for Networked Control of Distributed Energy Resources (DERConnect).

As indicated in the National Academies of Sciences, Engineering, and Medicine reports on Accelerating Decarbonization of the U.S. Energy System[1] and The Future of Electric Power in the United States[2], bold and decisive action is urgently required to address the need for clean energy. New resources are necessary to both initiate and accelerate new discovery, insights, and translation research pathways from exploratory concepts to technological solutions. NSF-funded workshops, on topics ranging from electrochemical energy storage[3] to a zero-carbon power grid[4], have identified new research directions that can help meet this global challenge.

Goals

Clean Energy Technology investments at NSF are designed to identify and support transformative research to advance U.S. leadership in the clean energy transition. Goals include:

- *Support fundamental research* in science and engineering to change paradigms and spawn innovations in clean energy supply, distribution, and use;
- *S*upport *convergent research engaging teams* of scientists and engineers to address interconnected problems inspired by the need to reshape the energy sector and related emerging industries;
- *Develop energy research infrastructure*, as well as the associated computing and communications infrastructure, necessary to generate fundamental knowledge and technologies for clean energy;
- *Translate innovations* through unique funding opportunities and partnerships that foster co-design, co-creation, piloting, and prototyping*;* and
- *Develop the clean energy workforce of the future* by attracting, inspiring, educating, training, and reskilling/upskilling diverse individuals, from K-12 to college and industry.

[1] https://nap.nationalacademies.org/catalog/25932/accelerating-decarbonization-of-the-us-energy-system
[2] https://nap.nationalacademies.org/catalog/25968/the-future-of-electric-power-in-the-united-states
[3] https://nsf.gov/awardsearch/showAward?AWD_ID=1942226
[4] https://nsf.gov/awardsearch/showAward?AWD_ID=2218933

FY 2024 Investments

The cross-NSF investments in Clean Energy Technology in FY 2024 support high-risk, high-reward research ideas across the science and engineering spectrum that create broad new understanding and innovations to support energy efficiency, enhance sustainability, adapt to and mitigate climate change, spawn new industries, and support translation and partnerships for innovation, as well as education and workforce development.

Fundamental and Convergent Research*:*
NSF will invest in fundamental, convergent clean-energy technology research to support: improvements in generation, capture, conversion, storage, and distribution of electricity and fuels; advancements in renewable clean-energy sources, including off-shore wind, hydrogen and fuel cells; development of new net-zero fuels and chemicals; more efficient energy usage; as well as research related to infrastructure and systems, such as industrial heat, decarbonization technologies, and interconnected natural, human-built, and social systems. NSF will invest in research related to behavioral economic, equity and regional drivers in design and implementation of clean energy technologies, as well as the human-technology interface. NSF will also invest in collaboration activities to advance grand challenges in clean energy frontiers.

Energy Research Infrastructure:
Investments in energy research infrastructure will allow for the creation of more energy-efficient energy systems, from capture and generation to distribution, for industry, transportation, buildings, and other uses. Investments in computing and communication research infrastructure will enable the creation of more efficient and sustainable hardware, software, and systems for computing and communication—a significant and growing component of U.S. electricity consumption. Energy research infrastructure investments will also afford piloting and prototyping of research-based solutions.

Innovation and Translation:
NSF accelerates the translation of research results to the market and society, catalyzing a broad spectrum of advanced energy technologies and systems. NSF speeds translation of fundamental discoveries in clean energy into technologies and systems through its Centers for Chemical Innovation, Expeditions in Computing, Engineering Research Centers, Materials Research Science and Engineering Centers, Materials Innovation Platforms, and Industry-University Cooperative Research Centers, as well as through the NSF Lab-to-Market Platform comprising Partnerships for Innovation, NSF Innovation Corps, and the Small Business Innovation Research and Small Business Technology Transfer programs. In FY 2024, NSF will add Biofoundries to the set of programs that fosters innovation and translation of biobased clean energy technologies. In addition, NSF partners and coordinates with federally supported Manufacturing USA Institutes, and with other agencies such as the Department of Energy and the Department of Defense to transition fundamental clean energy technology research further towards application.

Education and Workforce Development:
To prepare a diverse clean energy workforce across the Nation, NSF invests in the Advanced Technological Education, NSF Research Traineeship, Faculty Early Career Development, Research Experiences for Undergraduates Sites and Supplements, and Research Experiences for Teachers in Engineering and Computer Science programs, as well as clean energy technology education in

research projects and education research and development projects. NSF support for Non-Academic Research Internships for Graduate Students (INTERN) provides students with relevant experience beyond academia, including in government and industry settings. The Innovative Technology Experiences for Students and Teachers (ITEST) program provides support for projects that involve K-12 students in innovative use of technologies, including those related to clean energy. In addition, EDU has a suite of programs that support the underlying knowledge STEM education and workforce development from preK-12 to professional learning and in both formal and informal contexts.

U.S. GLOBAL CHANGE RESEARCH PROGRAM (USGCRP)

U.S. Global Change Research Program Funding[1]

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplmental Base	FY 2023 Estimate Total	FY 2024 Request REVISED
BIO	$162.01	$211.71	-	$211.71	$225.07
CISE	-	-	30.00	30.00	30.00
ENG	-	-	-	-	50.00
GEO Programs	337.60	345.60	10.00	355.60	479.46
GEO: OPP	236.00	197.26		197.26	197.26
MPS	13.44	12.00	-	12.00	14.63
SBE	19.92	20.00	-	20.00	25.14
OISE	11.99	7.50	8.00	15.50	12.50
IA	-	-	2.00	2.00	1.00
Total	**$780.96**	**$794.07**	**$50.00**	**$844.07**	**$1,035.06**

[1] Funding displayed may have overlap with other topics and programs.

Overview

As indicated in the Fourth National Climate Assessment[1], communities across the country and the world are experiencing the effects of a changing climate, including more frequent and severe flooding, more destructive wildfires, heavier rainfall, and more extreme heat waves. These and other climate changes are increasing the risk of infrastructure failure; disruption to vital public services; threats to ecosystems and species that provide benefits to people; and heat-related illness and death and other health impacts. In the U.S. and worldwide, we have experienced severe disruption to essential systems—including food, water, health, energy, transportation, and natural and managed ecosystems—that help keep people safe and healthy. People who are already vulnerable due to socioeconomic inequality and past and current marginalization are disproportionately harmed by the impacts of climate change and have lower capacity to adapt.[2,3]

The research needed to inform responses and solutions to these challenges require better understanding of climate and global change risks affecting interconnected natural and human systems, how the behavior of those systems affects risks to society, and the social context and consequences of measures to reduce risks. Enhancing the integration of social and natural sciences in all stages of research, and the use of transdisciplinary approaches to collaborative research, are critical to advancing knowledge and the ability to inform decisions. In addition, it is paramount that participation in global change research be more inclusive and engage with populations, communities, and organizations that face higher risks from climate and global change. USGCRP has fully recognized

[1] https://nca2018.globalchange.gov/

[2] www.ipcc.ch/report/ar6/wg2/

[3] https://nap.nationalacademies.org/catalog/26435/communities-climate-change-and-health-equity-proceedings-of-a-workshop

this need and has developed a framework in its new Strategic Plan (2022-2031)[4] to better equip the Nation and the world to respond to change and manage critical risks.

Goals

1. Advancing Science: Advance scientific knowledge of interconnected natural and human systems and risks to society from global change;
2. Engaging the Nation: Enhance the Nation's ability to understand and respond to global change by expanding participation in the Federal research enterprise;
3. Informing Decisions: Provide accessible, usable information to inform decisions on mitigation, adaptation, and resilience; and
4. Collaborating Internationally: Build global capacity to respond to global change through international cooperation and collaboration.

NSF investments in global change research span climate science, impacts, adaptation and mitigation strategies, and solutions. As part of NSF's holistic approach to addressing global change, NSF's investments aligned with USGCRP are complemented by investments in research to advance America's clean energy future—from foundational and use-inspired knowledge in physics, chemistry, biology, materials science, and computing to large-scale systems engineering, computation, and advanced cyberinfrastructure. More information on these complementary investments can be found in the Clean Energy Technology narrative in this chapter.

NSF addresses climate and global change issues through investments that advance frontiers of knowledge, provide state-of-the-art instrumentation and facilities, develop new analytical methods, and enable cross-disciplinary collaborations while also cultivating a diverse, highly trained workforce with access to educational resources to develop the next generation of global change researchers. NSF's climate and global change-related programs support the research and related activities to advance fundamental understanding of physical, chemical, biological, and human systems, and the interactions among them. Programs encourage interdisciplinary and integrated approaches to studying Earth system processes and the consequences of change, including how humans respond to changing environments and the impacts on ecosystems and the essential services they provide.

NSF invests in the fundamental research at the heart of global change issues. Long-term, continuous, and consistent observational records are essential for testing hypotheses quantitatively and are thus a cornerstone of global change research. NSF supports a variety of research observing and sensing networks that complement, and are dependent on, the climate monitoring systems maintained by its federal partners. The results of NSF investments have helped communities address challenges associated with resilience, mitigation, adaptation, and other responses to a changing environment.

NSF invests in broadening participation activities including capacity building, research centers, partnerships, and alliances. These investments seek to foster a just, equitable and inclusive research community that reflects the diversity of the U.S, develop a workforce with the skills required to understand how the Earth system can continue to sustain society, and engage with populations, communities, and organizations that are directly affected by global change.

[4] www.globalchange.gov/browse/reports/us-global-change-research-program-2022%E2%80%932031-strategic-plan

NSF invests in international partnerships to meet global change challenges by supporting research collaborations that foster team science, community-engaged research, and use knowledge-to-action frameworks. These convergent, interdisciplinary research collaborations bring together studies of any number of topics (such as greenhouse gas emissions, atmospheric and oceanic circulation drivers, impacts of natural and built environments, human behavior, and policy constraints) coupled with innovative artificial intelligence and computational and data science solutions, to help assess or mitigate community impacts and/or lead to technology developments.

Past investments have helped inform the National Climate Assessment and several other technical reports mandated by the Global Change Research Act of 1990. Investments have also aided U.S. communities to develop mitigation and adaptation strategies to address both challenges and opportunities derived from a changing environment. The fundamental knowledge gained through NSF disciplinary and cross-cutting programs focusing on the coupled natural-human-built system are critical in developing effective solutions to these challenges and capitalizing on opportunities.

FY 2024 USGCRP Funding

Several investments of note are planned in FY 2024. NSF will expand its activities related to risk and resilience, including new effort to build a comprehensive National Resilience Network which will focus on four key areas:

- improving climate hazard and disaster resilience in communities;
- developing technologies needed to advance resilience research;
- implementing a climate innovation challenge to determine the effectiveness, impact, and unintended consequences on proposed and already initiated climate interventions; and
- supporting research on the human health implications of climate change.

NSF will also initiate activities for new approaches for design in extreme environments to meet the challenges of the changing climate spanning rural and urban communities and natural and built environments, such as:

- sustainable, smart and resilient civil infrastructure and materials for extreme natural hazards and/or needs;
- robotics for extraordinary settings or human-robot interactions;
- agriculture and manufacturing for extreme sustainability; and
- semiconductors, microelectronics, and communications that meet extreme performance requirements.

NSF will continue to explore ways to identify and address barriers to equity and participation in the study of the Earth system. Efforts include enhancing the support of early-career researchers from a variety of institutions as well as ensuring support for postdoctoral fellows from groups underrepresented in global change fields of study. In FY 2024, NSF will start a special initiative to support Climate Equity Fellows. This program will train students and researchers in science important for addressing climate change and to be knowledgeable about the disparate impacts of climate change on disadvantaged or underserved communities and to integrate these perspectives into the design of their research projects.

Investments by Program Component Area (PCA)

USGCRP Funding by Program Componenet Area

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request REVISED
Multidisciplinary Earth and Human System Understanding	$405.22	$438.77	$28.00	$466.77	$576.08
Integrated Observations	281.86	271.97	4.00	275.97	282.07
Integrated Modeling	78.99	71.33	12.00	83.33	116.71
Science of Adaptation and Science to Inform Adaptation Decisions	14.89	12.00	6.00	18.00	45.20
Communication and Education	-	-	-	-	$15.00
TOTAL	**$780.96**	**$794.07**	**$50.00**	**$844.07**	**$1,035.06**

Multidisciplinary Earth and Human System Understanding:
NSF investments improve knowledge of the Earth's past and present climate variability through activities to document and understand climate cycles across the globe, as well as to better understand the natural variability of climate and the processes responsible for global changes using a range of paleoclimate, instrumental data, and modeling approaches. NSF also supports activities that advance our understanding of the complex interactions between, within and among the components of integrated socio-environmental systems, such as improving our understanding of the frequency and intensity of extreme climate events and the impacts of these events on natural and human systems.

Integrated Observations:
NSF supports advanced capabilities to observe the physical, chemical, biological, and human components of the Earth system over multiple space and time scales. Facilities such as the Academic Research Fleet, Ocean Observatories Initiative, and the National Ecological Observatory Network assist the Nation in gaining a fundamental scientific understanding of the Earth and monitor important variations, trends, and feedback processes between natural and human systems.

Integrated Modeling:
NSF will continue to devote significant resources to advancing climate and integrated modeling capabilities. Since there is increasingly deep interplay among observations and modeling at multiple spatial and temporal scales, a high priority will be given to developing more complete representations—models of coupled interactive atmospheric chemistry and processes, ecosystems, biogeochemical cycling, and integrated socio-environmental systems with predictive capabilities at regional and local scales. This will include continued investment in the National Discovery Cloud for Climate.

Science of Adaptation and Science to Inform Adaptation Decisions:
A key focus of the USGCRP is developing better means of assessing and responding to the impacts of global change as well as the vulnerability and resilience of both human and natural systems to those changes, particularly in highly sensitive regions in the Arctic and Antarctic. In addition to supporting research that will inform mitigation and adaptation decisions and extreme design in the age of climate change, NSF will support fundamental research regarding the science of adaptation, defined as the adjustment in natural and/or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.

Communication and Education*:*
In FY 2024, NSF will initiate a new effort to support Climate Equity Fellows. This program will train students and researchers in science important for addressing climate change and to be knowledgeable about the disparate impacts of climate change on disadvantaged or underserved communities and to integrate these perspectives into the design of their research projects.

CREATE OPPORTUNITIES EVERYWHERE

Description and Rationale

Create Opportunities Everywhere (COE) is a comprehensive approach for inspiring, attracting, supporting, and advancing groups underrepresented in STEM. This whole-of-NSF strategy incorporates all directorates and offices and surpasses prior investments by ensuring equity in program delivery and investing beyond NSF's broadening participation (BP) portfolio, while building on the concept of the "Missing Millions." This approach focuses on expanding diversity, equity, inclusion, and access in STEM by including underrepresented and underserved individual, institutional, and geographic characteristics. The National Science Board (NSB) conceptualized the Missing Missions as the difference between the demographics of the research community and the demographics of the nation and charged NSF with increasing opportunities that may lead to mitigating disparities that often contribute to talent gaps.[1] However, to do so, addressing both resource and representation gaps is critical. Resource gaps refer to gaps in financial resources, access to information and expertise, and the resources needed in increasing representation, such as cultivating, supporting, and advancing people from groups underrepresented in STEM as well as investigators and institutions in geographically diverse locations. Using this comprehensive approach to create opportunities everywhere, NSF will integrate diversity, equity, inclusion, and access into all program efforts to strengthen U.S. STEM education, research, and workforce pathways and infrastructures by drawing on the full extent of the Nation's talent and resources.

NSF is committed to identifying and addressing barriers to innovation, partnerships, experiences (formal and informal), and opportunities in STEM, both within the agency and in how it delivers programs to the thousands of institutions and organizations it supports. Historically, NSF invests significantly each year in its BP programs and projects across the country. An abundance of unrealized STEM potential is found in many communities, jurisdictions, and territories across the Nation. As a result, there is significant need to build upon the agency's BP portfolio of STEM education, workforce, innovation, and research programs, alliances, and models by incorporating the Missing Millions concept into the STEM enterprise. NSB, in its *Vision 2030* report, estimated that, in order for the S&E workforce to be representative of the U.S. population in FY 2030, the number of women in STEM must nearly double, Black or African Americans in STEM must more than double, and Hispanic or Latinos in STEM must triple the number who are in the 2020 U.S. S&E workforce.[2] These estimates are based on projections from the U.S. Census and Bureau of Labor Statistics, together with data from the National Center for Science and Engineering Statistics (NCSES).

NSF aims to fund projects that inspire, nurture, and advance diverse, domestic STEM talent from all communities, jurisdictions, and territories across the country. Eliminating disparities in cultivating STEM talent must involve a wide set of stakeholders, from *individuals* traditionally identified as underrepresented or underserved, to *institutions of higher education and informal science education institutions* that serve groups underrepresented in STEM, to those *communities (e.g., urban and rural), lands and jurisdictions* across the country that currently lack resources and opportunities for robust education, workforce development, and regional innovation. To be effective in creating opportunities everywhere, NSF must identify and embed guiding principles for COE across NSF's portfolio of

[1] www.nsf.gov/nsb/publications/2020/nsb202015.pdf
[2] www.nsf.gov/nsb/publications/2020/nsb202015.pdf

programs.

NSF has identified four guiding principles for creating and implementing opportunities everywhere. The principles guiding NSF's COE strategy are: (1) address research equity, (2) build capacity, (3) foster collaborations and partnerships, and (4) support the next generation of researchers. A focus on *Research Equity* ensures accessible and inclusive spaces for all STEM educators and researchers. To that end, investing in research to understand the science of broadening participation provides additional evidence-based approaches to support long-term efforts in this area. *Capacity Building* is more complex, but it is essential in reaching the Missing Millions of STEM. NSF investments in capacity building begin with support for PreK-12 students and teachers at high-need schools in rural, urban, and suburban communities and continue at the undergraduate and graduate levels to enhance the quality of STEM education and build research infrastructure at Minority Serving Institutions (MSIs) and emerging research institutions (ERIs). These investments commonly aim to improve STEM representation and success rates (i.e., graduation rates) among underserved students and increase diversity in STEM doctoral programs among domestic populations, which will contribute immensely to diversifying the U.S. STEM education and workforce enterprise. Capacity building also includes strategic investments in organizational infrastructures that support the application for and stewarding of funding in support of STEM research and training.

Initiating strategic partnerships, networks, and alliances as part of the COE strategy can lead to the development of national and international collaborations to scale research-based BP and equity efforts while fostering systemic change that addresses the intersection of multiple social identities, such as gender, race, ethnicity, and disability. The final guiding principle focuses on the Next Generation Researchers and STEM professionals, comprising current investments that are designed to support greater inclusion and equity in STEM academic professions. The facilitation of training, mentoring, and professional development opportunities are essential in building knowledge, expertise, and confidence as individuals move through multiple types of STEM career trajectories.

NSF's guiding principles for COE directly support the CHIPS and Science Act (P.L. 117-167) and enable NSF to build a strong domestic and diverse STEM workforce through a variety of partnerships and investments. Examples include: (1) expand the geographic and institutional diversity of research institutions and the students and researchers they serve through NSF's capacity building and broadening participation programs; and (2) promote research equity through supporting research on STEM participation, understanding bias and discrimination, as well as building the tools, surveys, and infrastructure necessary for understanding the impacts of Federally-funded research on society, the economy, and the workforce, including domestic job creation. Other examples include, but are not limited to: creating opportunities and incentives for centers to employ exemplary BP practices in STEM and ensuring implementation of such practices; supporting institutions to implement and study innovative approaches for building research capacity that engage and retain students from a range of institutions and diverse backgrounds in STEM; and working with emerging research institutions to build research capacity, support field and laboratory research experiences for undergraduate and graduate students, and enhance the availability of research instrumentation.

In FY 2024, NSF intends to apply the four guiding principles to create opportunities everywhere by strengthening and scaling investments and expanding beyond the BP portfolio. For *individuals*, NSF will continue to make investments in democratizing the STEM education and workforce. Stated differently, it will double down in its efforts to make STEM more diverse, inclusive, and accessible. For

institutions, NSF will be more intentional about how it engages MSIs and ERIs in its formal and informal programs, starting with those institutions classified as MSIs, but also focusing on the importance of MSI-bridge programs (e.g., funding open to all institutions that encourage participation by MSIs). To ensure equity in access, preparation, experiences, and program delivery, NSF has established an Agency Priority Goal designed to improve representation and ensure success in the science and engineering (S&E) enterprise by actions that will increase the number and proportion of proposals submitted by investigators that are underserved in STEM and from MSIs and ERIs.[3] For *jurisdictions (e.g.,* U.S. states and territories), NSF will expand support for individuals and institutions in EPSCoR jurisdictions to ensure geographic diversity, by seeking to close representational and resource gaps within the most underfunded regions of the U.S.

Goal of Investment

Creating opportunities everywhere requires a strategic and tactical approach to confronting current grand challenges to equitable success within the STEM enterprise. Thus, NSF has identified the following set of goals to guide its efforts in creating meaningful opportunities in STEM, while expanding the reach of NSF investments throughout the Nation's S&E enterprise and STEM ecosystem. These goals also reach across and beyond all of NSF's FY 2024 priority themes to Build a Resilient Planet, Advance Emerging Industries for National and Economic Security, and Strengthen Research Infrastructure. FY 2024 goals to COE include:

- Broaden the STEM Ecosystem: Expand NSF's programmatic efforts to under-resourced and underserved communities that cover a wide set of stakeholders, from individuals traditionally identified as underrepresented or underserved, to institutions of higher education and informal science education institutions. These institutions serve groups, communities, lands, and jurisdictions that are underrepresented in STEM, are not large recipients of federal research funding, or lack resources and opportunities for robust education, workforce development, and regional innovation. This goal directly supports the CHIPS and Science Act by supporting research and data collection to identify and lower barriers facing women, minorities, and other groups underrepresented in STEM as well expand research capacity within the Nation's HBCUs, TCUs, HSIs, other MSIs, and ERIs.
- Accelerate Student Success in STEM: Increase preK-12, undergraduate (2-year and 4-year institutions), graduate, and post-doctoral success in STEM disciplines among those from gender, racial, ethnic, geographic, and other groups who have been historically underrepresented in STEM disciplines and careers. This directly supports the CHIPS and Science Act to address diversity in formal and informal STEM education at all levels, including preK-12, undergraduate and graduate education. For example, in FY 2023, NSF launched the Experiential Learning for Emerging and Novel Technologies (ExLENT) program with the goal of scaling efforts to support inclusive learning opportunities designed to provide cohorts of diverse learners with the crucial skills needed to succeed in key technology focus areas and prepare them to enter the workforce ready to solve the Nation's most pressing societal, economic, national, and geostrategic challenges. Further, Components that focus on diversity include increasing diversity in the STEM teacher workforce and facilitating the development of networks and partnerships to advance broadening participation research under the Eddie Bernice Johnson INCLUDES Initiative, supporting activities that address the diversification of the STEM workforce by focusing on the needs of undergraduate and graduate faculty and students, while seeking to increase submissions from MSI's, such as

[3] NSF FY 2022-FY 2023 Annual Performance Plan www.nsf.gov/about/budget/fy2023/pdf/90_fy2023.pdf

HBCUs, HSIs, TCUs, and other broad access institutions with significant numbers of students of color.

- Strengthen Educational Institutions through Collaborative Programs and Partnerships: Strengthen leadership development and advancement opportunities for faculty at MSIs and ERIs to foster PI and institutional success in STEM and STEM education research through a collaborative infrastructure of networks, alliances, and partnerships to broaden participation of individuals, groups, and localities/regions often excluded or underserved in STEM.
- Accelerate Inclusion and Access in NSF's Research Portfolio: Increase and strengthen institution and faculty engagement in NSF's many research programs and activities from those institutions not currently well represented in NSF's research programs through strategic outreach and engagement activities and programs intended to build capacity and competitiveness for these programs.
- Develop an Evidence Foundation for COE: Continuously inform COE efforts by supporting empirical research and the necessary and underlying research infrastructure. Such research provides theories, methods, and analytic techniques to better understand individual and compounded factors that enhance and impede the Nation's ability to expand participation in STEM education and the workforce and throughout all economic and social institutions in society. This will be an important foundation for realizing the goal of broadening participation in science and engineering (e.g., The CHIPS and Science Act, Titles III and IV). One key activity in support of this goal is the Analytics for Equity initiative, which was initiated in FY 2023. This initiative builds on the Evidence-Based Policymaking Act and E.O.13985[4] by piloting a new way to support social, economic, and behavioral sciences research that leverages federal data assets (ensuring privacy is protected and data are secure) and scientific advances in researching equity-related topics for greater public benefit. This goal addresses CHIPS and Science Act provisions, which direct NSF to support awards that measure the impacts of Federally funded research by collecting and analyzing data STEM participant demographics in federally funded awards.

Achieving these goals is likely to strengthen the capacity and capabilities of institutions and investigators who are frequently underrepresented and underserved in STEM and reduce barriers throughout the S&E enterprise and STEM ecosystem. These efforts are designed to enable greater access to all science and engineering research and education resources in emerging and novel STEM fields, enabling new technological innovations and cutting-edge modes of employment necessary for American prosperity.

Potential for Impact, Urgency, and Readiness

NSF has had a long-standing goal of cultivating a world-class, broadly inclusive science and engineering workforce while expanding the scientific literacy of all citizens. NSF has continuously invested in foundational, curiosity-driven, discovery-oriented research and use-inspired, solutions-oriented projects. As the Nation transitions, transforms, and innovates while confronting grand challenges in reaching the Missing Millions in STEM, NSF's defining role in developing STEM talent everywhere benefits the U.S. global leadership in STEM and advances the Nation's science and engineering competitiveness through its ability to inspire curiosity, support creativity, and stimulate innovation.

[4] www.federalregister.gov/documents/2021/01/25/2021-01753/advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government.gov

NSF recognizes the historical and emerging challenges in the U.S. workforce and what that could mean for the STEM workforce of the future. Although we have made progress in promoting STEM education and a STEM workforce that includes all Americans (*Women, Minorities, and Persons with Disabilities in Science and Engineering*, NCSES, 2023),[5] persistent disparities remain and are at risk of worsening in the post-pandemic environment. Along with other inequities, those in education and employment are extremely salient[6]. NSF must enhance and accelerate its efforts to diversify STEM education and the STEM workforce. Over the years, through its BP portfolio, NSF has intentionally focused on equity in science and engineering, and now NSF must ensure that these efforts are reaching all parts of the U.S., regardless of geographic location, or type of organization or institution. For more detail regarding investments in broadening participation, please see the table of BP programs in the Summary Tables chapter.

There is a critical need to acknowledge, understand, value, and study the aforementioned topics to fundamentally drive success in the Nation's S&E enterprise. To this end, FY 2024 investments in COE will build on NSF's agency-wide annual investment to broaden participation in STEM, which has already created new knowledge and expanded research and training readiness across a diverse landscape of institutions. NSF has increasingly invested in BP programs over the past several decades, building individual and institutional capacity and a strong knowledge base. NSF is unique in that it supports all areas of science and engineering as well as encouraging interdisciplinary science, engineering, and education in the many programs that it supports. Science and engineering research communities are supportive and ready to tackle these challenges (see, for example, the biannual Committee on Equal Opportunity in Science and Engineering (CEOSE) reports to Congress, *Vision 2030* from the NSB, and the new *Envisioning the Future of NSF EPSCoR* report).[7] NSF has identified new areas for investments targeting disparities in STEM education and the STEM workforce across all of its directorates and capitalizes on points of intersection to assist members of the STEM community in recognizing opportunities relevant to their needs.

In FY 2022, NSF published its FY 2022-2026 Strategic Plan *Leading the World in Discovery and Innovation, STEM Talent Development, and the Delivery of Benefits from Research.*[8] The vision articulated in the plan is foundational to COE: A nation that leads the world in science and engineering research and innovation, to the benefit of all, without barriers to participation. And within the plan's first Strategic Goal, *Empower*, NSF defines the Agency Priority Goal: to improve representation in the S&E enterprise but also leverages its learning agenda goal (How can NSF grow STEM talent and opportunities for all Americans most equitably?) and a multitude of other activities, including acting upon recommendations from NSF's racial equity task force, responses to several equity-related Executive Orders on "Advancing Racial Equity and Support for Underserved Communities Through the Federal

[5] *Women, Minorities, and Persons with Disabilities in Science and Engineering*, NSF/SBE/NCSES. NSF 23-315, January 30, 2023. https://ncses.nsf.gov/pubs/nsf23315/

[6] www.bls.gov/emp/tables/stem-employment.htm; www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/

[7] CEOSE, www.nsf.gov/od/oia/activities/ceose/index.jsp. NSB, www.nsf.gov/nsb/NSBActivities/vision-2030.jsp. EPSCoR, https://nsf-gov-resources.nsf.gov/2022-08/Envisioning-The-Future-of-EPSCoR-Report.pdf

[8] NSF's FY 2022-2026 Strategic Plan: www.nsf.gov/about/performance/strategic_plan.jsp.

Government"[9] and advancing equity in science and technology,[10] and integrating outcomes from working groups throughout NSF that are increasing agency collaboration and coordination to the benefit of groups that are underrepresented and underserved in STEM.

Through NSF's FY 2024 COE investments, NSF will leverage intentional alignment of strategy and actions to broaden participation of groups underrepresented in STEM to ensure that NSF's portfolio of programs is broadly accessible and inclusive. To this end, COE will enable the scaling of established programs and introduction of new initiatives to ensure that talent is energized across broad socioeconomic demographic and geographic diversity. At the core of NSF's approach is a commitment to building strong partnerships across communities, institutions, agencies, industries, and nations to create powerful global STEM and innovation ecosystems. The aforementioned efforts are key to accelerating the frontiers of science, engineering, and technology for decades to come.

Anticipated Potential Contributors

NSF's investments in COE are crosscutting and will include contributions from all of NSF's directorates and offices.

[9] www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/

[10] www.whitehouse.gov/ostp/news-updates/2021/10/14/the-white-house-office-of-science-and-technology-policy-launches-the-time-is-now-advancing-equity-in-science-and-technology-ideation-challenge/
www.whitehouse.gov/ostp/news-updates/2022/05/26/new-guidance-to-ensure-federally-funded-research-data-equitably-benefits-all-of-america/

RESEARCH INFRASTRUCTURE THEME

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

STRENGTHEN RESEARCH INFRASTRUCTURE

Description and Rationale

Research infrastructure (RI), from individual instruments to major research facilities, is foundational to the scientific endeavor. Definitions of RI have evolved significantly over the years, particularly as remote access and cyberinfrastructure have become essential components of almost every tool in use by the research community. The COVID-19 pandemic further emphasized the critical nature of these components and illustrated how they contribute to ongoing efforts to expand access to RI to historically underserved groups and communities. Additionally, NSF investments in science and engineering have stimulated discovery and innovation in the design and development of novel infrastructure, giving rise to new and different forms of RI.

The National Science and Technology Council's (NSTC) *National Strategic Overview for Research and Development Infrastructure*[1] defines Research and Development Infrastructure (RDI) as "facilities or systems used by scientific and technical communities to conduct research and development (R&D) or foster innovation." The report goes on to note that "RDI elements include experimental and observational infrastructure, knowledge infrastructure, and research cyberinfrastructure—all of which are integrated resources relied upon by our Nation's R&D enterprise." NSF follows this broadly inclusive definition for RI throughout.

RI is an essential enabler of science and engineering research and education. It is needed for all forms of fundamental research – from curiosity-driven, exploratory research to use-inspired, solutions-oriented research. RI is critical to the success of research across a wide array of disciplines and over a broad range of time scales. Investments in RI enable advances in areas as varied as measurement of the evolution of carbon in the atmosphere, assessment of the rate at which glaciers are losing ice, analysis of the changes in biomass in forests (see the Build A Resilient Planet narrative for more details), studies of the rate at which members of underrepresented groups are engaged in science and engineering disciplines, modeling of the epidemiology of infectious diseases, detection of gravitational waves, the search for dark matter and dark energy, investigation of the fundamental structure of particles that make up everything in the universe, studies of biological, chemical, and physical processes at femtosecond and attosecond timescales, and characterization of the contents of our solar system (including potentially hazardous asteroids). RI also plays an important role in development of advanced wireless communications, research on new nanomaterials and design of new biomaterials, refinement of meteorological and space weather models and forecasts, creation of AI algorithms for a variety of societal uses, and the development of quantum computing and communication capabilities.

Importantly, RI expands to comprise instrumented and living laboratories and testbeds, enabling advances in Emerging Industries (see the Advance Emerging Industries for National and Economic Security narrative for more details), as well as collection of multi-sensor, human observation, and behavioral data. Modern RI for fundamental research and innovation gathers and processes vast amounts of data, makes sense of those data using analytics, computational modeling and simulation, and AI, and supplies both raw and processed data to researchers across the U.S. and around the world. Accordingly, advanced cyberinfrastructure is increasingly a vital aspect of all successful RI. New

[1] www.whitehouse.gov/wp-content/uploads/2021/10/NSTC-NSO-RDI-_REV_FINAL-10-2021.pdf

and new types of RI is anticipated to enable NSF's support of provisions in the CHIPS and Science Act.

Cutting-edge RI is also integral to attracting, developing, and training the next generation of STEM talent and inspiring those who will lead the next generation of advances in infrastructure. The skills required to design, build, operate, and maintain RI are critical for the future of the Nation's STEM enterprise, including individuals from skilled technical workers to PhDs.

In short, investments in research must be complemented by corresponding investments in RI in order for the U.S. to lead the world in science and innovation.

Goal of Investment

Strengthening Research Infrastructure promotes a stronger, U.S.-led science and engineering enterprise and STEM ecosystem. NSF's RI portfolio uniquely positions the agency to support research advances that are not enabled by other federal entities. Intentional investments in RI are pillars that buttress NSF's efforts to Create Opportunities Everywhere, Build a Resilient Planet, and Advance Emerging Industries for National and Economic Security. Overarching goals for FY 2024 include:

- Sustain state-of-the-art RI to foster discoveries and innovation at the forefront of a wide range of science and engineering disciplines.
- Leverage new and existing RI to enhance our understanding of and address societal challenges, such as U.S. competitiveness, biosecurity, climate change, and socioeconomic and regional inequities. This includes expanding our knowledge of the Earth's atmosphere, ocean, land, and ice surfaces using the sensors and data made available through major and mid-scale research infrastructure, characterizing near-Earth objects and providing computational capacity to simulate biological organisms such as viruses.
- Boost access to RI to all groups across the socioeconomic spectrum, with particular attention to communities and regions that have historically been underrepresented in science and engineering. Without access to the RI needed for research, other equity and broadening participation efforts cannot reach their full potential.
- Sharpen RI's focus on workforce development with continued emphasis on training students and the skilled technical workforce in the design and implementation of infrastructure to ensure a technically proficient and diverse workforce.

Potential for Impact, Urgency, and Readiness

In addition to establishing a definition for RDI, the NSTC's *National Strategic Overview for Research and Development Infrastructure* laid out a strategic vision for Federal government investments that emphasized the importance of RDI in maintaining U.S. national security and economic competitiveness. The report further acknowledged the importance of integrating input from the R&D community, such as that NSF routinely receives from its advisory committees and the National Science Board, and from studies conducted by the National Academies of Sciences, Engineering and Medicine (NASEM). Recent NASEM reports[2] continue to guide NSF's investments in new and established RI.

[2] For example, National Academies of Sciences, Engineering, and Medicine. 2021. *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26141; National Academies of Sciences, Engineering, and Medicine. 2020. *A Vision for*

Continued investment in RI is critical for maintaining U.S. leadership in scientific research and innovation. RI is often the key ingredient that makes cutting-edge science and discovery possible and, consequently, demand is high. NSF's Mid-scale RI programs are many-fold oversubscribed and research communities across many STEM fields have released ambitious plans involving acquisition or construction of new infrastructure to support their science goals. Exciting and robust RI is essential to achieving equitable participation by all in careers in science and engineering. Programs associated with RI that engage and attract groups underrepresented in STEM must be a growing part of NSF's investment in RI, and likewise, investments in expanding the accessibility of RI may often be the key ingredients that help a broader cross-section of Americans engage in STEM research.

NSF's investments in RI span a range of activity types. For ease of reading, these examples are divided below into the separate categories of fundamental research and enabling broader access to RI, but there is considerable overlap among these categories, and many investments would benefit both focus areas.

Activities with a focus on fundamental research:

- Support for Antarctic infrastructure and logistics to enable researchers to access remote areas of the Antarctic continent (both in person and virtually).
- Investment in the physical infrastructure of NSF's major facilities, targeting those that study the Earth's biosphere, atmosphere, and oceans, contributing to the U.S. Global Change Research Program (USGCRP), as well as those in which aging of the physical infrastructure now threatens the ability to deliver forefront science.
- Construction of the Leadership-Class Computing Facility (LCCF) to meet the increasing demand for large-scale computing and data analytics capabilities, while minimizing gaps in resource availability as the current system (*Frontera*) obsolesces.

Activities that specifically enable broader access to RI:

- Funding cybersecurity and cyberinfrastructure at selected major facilities and in campus cyberinfrastructure and other key points of connection, to improve and secure virtual access to broader communities.
- Investment in mid-scale RI, with an emphasis on projects that enhance the engagement of a diverse workforce in the design, implementation, and ultimate use of RI.[3] At the FY 2024 Budget level, additional Mid-scale RI Track 1 ($6-20 million range) and Track 2 ($20-100 million range) awards will be possible, providing more capacity for innovative developments that expand the STEM workforce and provide cutting-edge RI to previously underserved communities.
- Investment in major research instrumentation (MRI), with a sustained commitment to invest in predominantly undergraduate institutions, historically under-resourced institutions, and geographic diversity.

NSF Earth Sciences 2020-2030: Earth in Time. Washington, DC: The National Academies Press. https://doi.org/10.17226/25761; National Academies of Sciences, Engineering, and Medicine. 2021. *Mid-Term Assessment of Progress on the 2015 Strategic Vision for Antarctic and Southern Ocean Research*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26338.

[3] For example, in the first round of the NSF-wide Mid-scale Research Infrastructure solicitations, NSF funded a network of advanced Nuclear Magnetic Resonance spectrometers that will specifically enable research at smaller universities and Minority Serving Institutions that have not previously had access to such infrastructure.

- Enhancement of programs at major facilities that provide opportunities for engaging the skilled technical workforce, such as internships focused on electronics, equipment operation and repair, and partnerships with technical and community colleges.

Directorate Contributions to Research Infrastructure

In FY 2024, BIO will continue to invest in the National Ecological Observatory Network by expanding the biorepository capacity. CISE, through its Office of Advanced Cyberinfrastructure, will oversee the construction of LCCF and will support cyberinfrastructure and cybersecurity efforts at major facilities through an internal NSF working group. GEO and MPS will continue to provide operations and maintenance (O&M) funding to major facilities, with a focus on maintaining state-of-the-art capability and addressing deferred maintenance items and upgrades. Additional investment in logistics support for the U.S. Antarctic Program will enable OPP to advance critical climate-focused research in West Antarctica, where glacial instabilities have been recently discovered. OIA administers the MRI and Mid-scale RI Track 1 programs, in which all directorates are overseeing funded projects. The requested funding level in FY 2024 will enable more awards in each of these programs, expanding access to cutting-edge RI to a broader population of researchers and students. All directorates support research resources, smaller scale RI that nonetheless enables discovery and innovation across NSF's portfolio of awards. Finally, through SBE's National Center for Science and Engineering Statistics, further investment will be made in the America's Data Hub Consortium to expand provision of and access to data from Federal agencies.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION ACCOUNT (MREFC) OVERVIEW

$304,670,000

Major Research Equipment and Facilities Construction Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Esimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Percent
$120.60	$187.23	$304.67	$117.44	62.7%

Overview

The MREFC account supports the acquisition, construction, and commissioning of major facilities and larger mid-scale research infrastructure that provide unique capabilities at the frontiers of science and engineering. Initial development and design and post-construction operations and maintenance are funded through the R&RA account.

MREFC Account Funding, by Project

(Dollars in Millions)

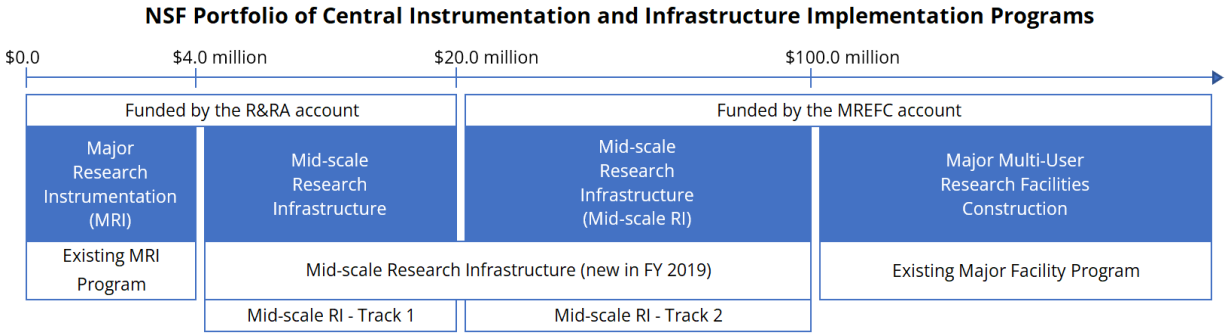
	FY 2022 Actual[1]	FY 2023 Estimate	FY 2024 Request	FY 2025 Estimate	FY 2026 Estimate	FY 2027 Estimate	FY 2028 Estimate	FY 2029 Estimate
Antarctic Infrastructure Recapitalization (AIR)	$55.20	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
HL-Large Hadron Collider Upgrade	10.58	33.00	38.00	-	-	-	-	-
Leadership-Class Computing Facility (LCCF)	-	-	93.00	247.00	147.00	33.00	-	-
Mid-scale Research Infrastructure, Track 2[2]	36.67	76.25	105.06	85.00	90.00	100.00	100.00	100.00
Regional Class Research Vessel (RCRV)[3]	-	1.98	-	-	-	-	-	-
Vera C. Rubin Observatory (Rubin)	17.49	15.00	7.61	-	-	-	-	-
Dedicated Construction Oversight	0.65	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Total	**$120.60**	**$187.23**	**$304.67**	**$393.00**	**$298.00**	**$194.00**	**$161.00**	**$161.00**

[1] A total of $330.73 million was carried over from FY 2022 to FY 2023: $98.34 million for Mid-scale; $150.65 million for AIR; $6.50 millon for RCRV; $20,467 for the Daniel K. Inouye Solar Telescope (DKIST); $29.68 million for HL-LHC, and $40.0 million for Rubin, $1.18 million for Dedicated Construction Oversight. THe remaining $4.36 million consists of funds from recoveries from old projects not funded in FY 2022.

[2] Outyear amounts are for planning purposes only. NSF will evaluate Mid-scale RI in the context of agency priorities for future budget submissions.

[3] FY 2022 Actual excludes $25.0 million in one-time funding for necessary expenses related to RCRV construction impacted by Hurricane Ida as provided in P.L. 117-43, the "Extending Government Funding and Delivering Emergency Assistance Act."

Modern and effective research infrastructure is critical to maintaining U.S. international leadership in science and engineering. The future success of entire fields of research depends upon access to new generations of powerful research tools. Over time, these tools are becoming larger and more technically complex and have significant information technology or cyberinfrastructure component. To be considered for MREFC funding, NSF requires that a major multi-user research facility (major facility) project represent an exceptional opportunity to enable research and education. The project should be transformative in nature, with the potential to shift the paradigm in scientific understanding. The major facility projects included in this budget request meet these criteria based on NSF and National Science Board review and approval. The mid-scale research infrastructure projects funded through this budget line are evaluated separately as described in a distinct section below.



The graphic above summarizes NSF's centralized instrumentation and infrastructure programs. Information presented in this chapter focuses on the items funded at levels above $20.0 million, through the MREFC account. All Mid-scale Research Infrastructure (RI) – Track 2 (Mid-scale RI-2) investments are managed as a single portfolio, with individual projects selected from submissions to a dedicated program solicitation that are evaluated using NSF's merit review process. The NSF-established thresholds for Mid-scale RI-2 projects and major facilities construction projects are consistent with definitions in the 2017 American Innovation and Competitiveness Act (AICA), as amended by the National Defense Authorization Act (NDAA) for FY 2021.

In FY 2024, NSF requests a total of $304.67 million to support mid-scale research infrastructure, initiation of construction of the Leadership-Class Computing Facility (LCCF), and continued construction on three ongoing major facility projects; Antarctic Infrastructure Recapitalization (AIR), the High Luminosity-Large Hadron Collider (HL-LHC) Upgrade, and the Vera C. Rubin Observatory. For more information on each major facility project, see the individual narratives later in this chapter.

Major Facilities

Since FY 2009, major facility projects funded through the MREFC account have been subject to NSF's "no cost overrun" policy. As a result, NSF processes and procedures must assure the development of realistic and well-supported total project cost estimates so that approved budgets for the award recipient are sufficient to accomplish the scientific objectives. The current policy, as published in NSF's Research Infrastructure Guide (RIG), requires that: (1) the total project cost estimate when exiting the preliminary design phase includes adequate contingency to cover foreseeable risks manageable by the recipient; (2) any cost increases not covered by contingency be accommodated first by reductions in scope, with any significant scope reductions reviewed by the agency prior to implementation; and (3) if the project is approved to continue and further scope reductions become too detrimental to science, then the first 10 percent of any cost increase must be covered by the sponsoring directorate through R&RA funding. NSF holds the risk to total project cost for unforeseen events that are beyond the recipient's control. The COVID-19 pandemic constituted such an unforeseen event for all major facility construction projects, and mitigation of that risk falls outside the "no cost overrun policy" and cannot be addressed through the use of contingency. NSF policy allows for both authorization of management reserve and re-baselining, with a subsequent increase in total project cost, to address the consequences of unforeseen events. The overall NSF response to COVID-19 for its major facilities is described at the end of this section.

Mid-scale Research Infrastructure

AICA required the agency to develop a strategy for supporting research infrastructure with a total project cost above the upper limit for the MRI program, which is $6.0 million including cost sharing, and below the lower threshold for the MREFC account, which was then at $70.0 million. The CHIPS and Science Act of 2022 waives the required cost-sharing for the MRI program for a period of five years. NSF has lowered the threshold for Mid-scale RI-Track 1 proposals in response, starting with the current solicitation (NSF 22-637). NSF assessed community demand via a Request for Information[1] that resulted in the submission of approximately $10.0 billion in ideas for projects in the NSF cost range of $20.0–$100.0 million. After evaluating that community input, existing mechanisms, and implementation options, NSF included a dedicated funding line within the MREFC account beginning in FY 2020 for research infrastructure projects in the $20.0–$70.0 million range. The upper limit has been increased to $100.0 million in the second Mid-scale RI-2 solicitation to align with the lower threshold defining a major facility project as given in the FY 2021 NDAA that amended the original AICA definition. This funding line supports upgrades to major facilities as well as stand-alone projects. Projects between $6.0 million and $20.0 million in total project cost are addressed by individual directorates and an NSF-wide program (Mid-scale RI-1) that draws its heritage from the NSF-wide MRI program.

Dedicated Construction Oversight

All major facility projects funded through the MREFC account undergo periodic cost, schedule, and risk reviews as required by the RIG and the terms and conditions of the cooperative agreements or contracts governing the projects. NSF policies and routine reporting are designed to ensure timely and reliable tracking of progress, including monitoring of project schedule and cost (*via* Earned Value Management metrics) and use of contingency, ensuring that program managers and recipients each have timely information to provide sufficient oversight and management authority, respectively, to meet project objectives.

Enhanced oversight of the construction stage includes mandatory incurred cost audits, Earned Value Management System surveillance, and independent cost estimates of re-baseline proposals, as well as other audits and reviews based on NSF's annual major facility portfolio risk assessment. These efforts are conducted by NSF and are generally not attributable to a specific project at the time of budget formulation, nor are they part of the total project cost developed and managed by the recipient. To properly support and transparently account for these efforts, actual costs and future estimates for Dedicated Construction Oversight are shown separately from the costs of individual projects in the MREFC account table above.

Oversight of the mid-scale research infrastructure projects is more flexible and tailored to the technical nature of each project. All mid-scale research infrastructure projects funded through the MREFC account are required to provide a detailed Project Execution Plan for review. The RIG, Section 5, notes that the detailed oversight requirements, and application of major facility oversight practices, depend on characteristics such as the technical scope, type and mix of work performed, and assessment of the technical and programmatic risks.

[1] NSF 18-013: Dear Colleague Letter: Request for Information on Mid-scale Research Infrastructure. Available at https://nsf.gov/pubs/2018/nsf18013/nsf18013.jsp

Continued COVID-19 Impacts on MREFC Projects

From FY 2020 and through FY 2022, NSF increased investments in programs that aid institutions and groups of people most strongly impacted by COVID-19, with an emphasis on supporting individuals at vulnerable career transition points. The COVID-19 pandemic constitutes an unforeseen event that was not within the control of the recipients managing the ongoing major facility construction projects. NSF had policies for responding to unforeseen events that were established in advance of the COVID-19 pandemic, which subsequently have been further refined to support the agency's response to pandemic impacts.

In FY 2021, Congress passed the American Rescue Plan Act (ARP). Within NSF's awarded amount, $55.48 million went towards mitigating COVID-19 impacts on several NSF research infrastructure projects within the MREFC account. Projects include: the Daniel K. Inouye Solar Telescope (DKIST, $8.95 million), the Vera C. Rubin Observatory ($30.0 million), Mid-scale RI-2 ($2.48 million), and RCRV, ($14.05 million). Accordingly, funding requests for FY 2022 and subsequent years for all projects have been adjusted from previous estimates based on NSF's current assessment of pandemic impacts. Re-baselining of several projects, resulting in revised total project costs and schedules, has taken place (e.g., RCRV, Rubin Observatory, and AIR). Re-baselining of HL-LHC is anticipated in FY 2024 as cost and schedule impacts become better known. Impacts due to COVID-19 that can now be forecast (e.g., higher personnel costs and slower progress due to known social-distancing and quarantining requirements) are included in the re-baseline as known risks to be addressed through budget contingency. Potential impacts that cannot be forecast (e.g., deteriorating circumstances because of the impact of new COVID-19 variants and lingering supply chain issues) are held as agency-level risks that would be covered by application of management reserve, in accordance with existing policy described in the RIG. Further details for each project can be found in the individual narratives later in this chapter.

For appropriations language and the carryover statement for the MREFC Account, see the Technical Information chapter.

ANTARCTIC INFRASTRUCTURE RECAPITALIZATION (AIR) $60,000,000

Appropriated and Requested MREFC Funds for the
for the Antarctic Infrastructure Modernization for Science (AIMS) Project and the
Antarctic Infrastructure Recapitalization (AIR) Program
(Dollars in Millions)

	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023 Estimate	FY 2024 Request	Total Project
Authorized AIMS Total Project Cost	$103.70	$97.89	$90.00	$90.00	$28.81	-	$410.40
COVID-19 Adjustment	-	-19.40	-	-	-	-	-19.40
Unfunded AIMS scope transferred to AIR	-	-	-	-87.19	-28.81	-	-116.00
Revised Estimated AIMS Total Project Cost	$103.70	$78.49	$90.00	$2.81	-	-	$275.00
AIR Request	-	-	-	87.19	60.00	60.00	TBD
AIMS+AIR TOTAL	**$103.70**	**$78.49**	**$90.00**	**$90.00**	**$60.00**	**$60.00**	**TBD**

Brief Description

The Antarctic Infrastructure Recapitalization (AIR) program is a portfolio of investments in facilities and infrastructure across U.S. Antarctic Program (USAP) stations and gateways that will assure safety, enhance efficiency, increase resilience, and support USAP's continued scientific leadership on the continent. As discussed below, FY 2022 funding supported the newly re-baselined Antarctic Infrastructure Modernization for Science project (AIMS) and initial activities within the broader recapitalization portfolio of NSF's Antarctic infrastructure under the AIR program.

Previously funded AIMS construction continues, with a focus on meeting near-term needs—the Vehicle Equipment and Operations Center and the Lodging Building. The FY 2023 and FY 2024 Requests of $60.0 million each will be used to fund activities within the AIR program exclusively.

Baseline History

In 2011, the Office of Science and Technology Policy and NSF convened a Blue Ribbon Panel (BRP) to conduct a review of NSF facilities and operations supporting science in Antarctica and to ensure that those facilities could enable scientific opportunities articulated by an earlier 2011 National Research Council (NRC) report, *Future Science Opportunities in Antarctica and the Southern Ocean.*[1] The BRP report, *More and Better Science in Antarctica Through Increased Logistical Effectiveness,*[2] made numerous recommendations to maintain and enhance the USAP's ability to support world-class science in Antarctica.

NSF responded to the BRP report by immediately addressing issues of safety, implementing operational efficiencies that resulted in a rapid return on investment, and developing long-term infrastructure plans for each of the three year-round U.S. stations: Palmer, Amundsen-Scott South Pole, and McMurdo. The AIMS project was a pivotal component of the McMurdo Station Master Plan. The AIR program will continue to refine and carry forward those long-term plans for the three USAP stations.

[1] www.nap.edu/catalog/13169/future-science-opportunities-in-antarctica-and-the-southern-ocean
[2] www.nsf.gov/geo/opp/usap_special_review/usap_brp/rpt/index.jsp

The AIR program will meet critical science needs while engaging the community and stakeholders broadly in an ongoing infrastructure renewal program that will keep the U.S. at the forefront of Antarctic research. AIR will assure safety, enhance efficiency and sustainability, increase resilience, and fulfill NSF's mandate of continued leadership on the continent.

The AIR program comprises a portfolio of investments that improve general-purpose USAP infrastructure including facilities, utilities, equipment, and fleet equipment. This critical infrastructure supports all fields of science. Investments are prioritized across all USAP locations, and acquisition strategies are tailored to individual activities.

Project Status

To manage the severe risks of introducing COVID-19 to Antarctica, on-site AIMS work at McMurdo was paused in March 2020 and construction personnel were not deployed to McMurdo for the FY 2021 or FY 2022 construction seasons. On-ice construction for AIMS resumed in late CY 2022.

Work was initiated in FY 2022 on the highest priority AIR activity—the McMurdo Pier Project, which will dramatically reduce programmatic risk. The McMurdo Pier Project was fully funded in FY 2022 and is being executed through an Inter-Agency Agreement with the U.S. Army Corps of Engineers.

Meeting Intellectual Community Needs

- The need for upgrades in many components of Antarctic infrastructure was informed by the 2011 NRC report and the 2012 BRP report. Additionally, the critical need to flexibly support a broad range of Antarctic research was further affirmed in a 2015 NRC report, *A Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research* and in the 2022 follow-on mid-term assessment.[3,4]
- Members of the research community participated in requirements development and refinement in the planning and design stages for AIMS, as well as in design reviews.
- Community engagement was intrinsic to the development of the McMurdo and Palmer Station master plans—critical documents that describe the future desired state of the respective stations and inform the AIR Program—and will again be sought in routine updates to the plans for each station. Similarly, community input will be central to the development of the South Pole master plan.
- The research community, through the merit review process, informs OPP's focus areas for logistics support. For example, through this process, the case was made for the West Antarctic Ice Sheet Divide field camp from which logistics support for the Thwaites Glacier project is based.

[3] www.nap.edu/catalog/21741/a-strategic-vision-for-nsf-investments-in-antarctic-and-southern-ocean-research
[4] https://nap.nationalacademies.org/read/26338/chapter/1

Governance Structure and Partnerships

NSF Governance Structure

The AIR program is managed by GEO and implemented by the OPP Antarctic Infrastructure and Logistics (AIL) section. For oversight of AIR, NSF tailors the best practices outlined by NSF's Research Infrastructure Guide, which includes the use of independent cost estimates where appropriate, routine status reports at the program and activity level, and periodic reviews of the portfolio by internal and external experts. The AIR program is overseen by NSF's Chief Officer for Research Facilities and by a Capital Investment Review Board (CIRB) that includes representatives from OPP's AIL, Antarctic Sciences section, Polar Safety and Occupational Health section, and NSF's MPS directorate, as well as representatives from the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration (NOAA), and military partners.

Partnerships and Other Funding Sources

NOAA is partnering with NSF to support upgrading satellite weather/communications data down/uplink facilities. That project is separate from, but will complement, AIR in modernizing McMurdo Station and facilitating future communication improvements.

Cost and Schedule

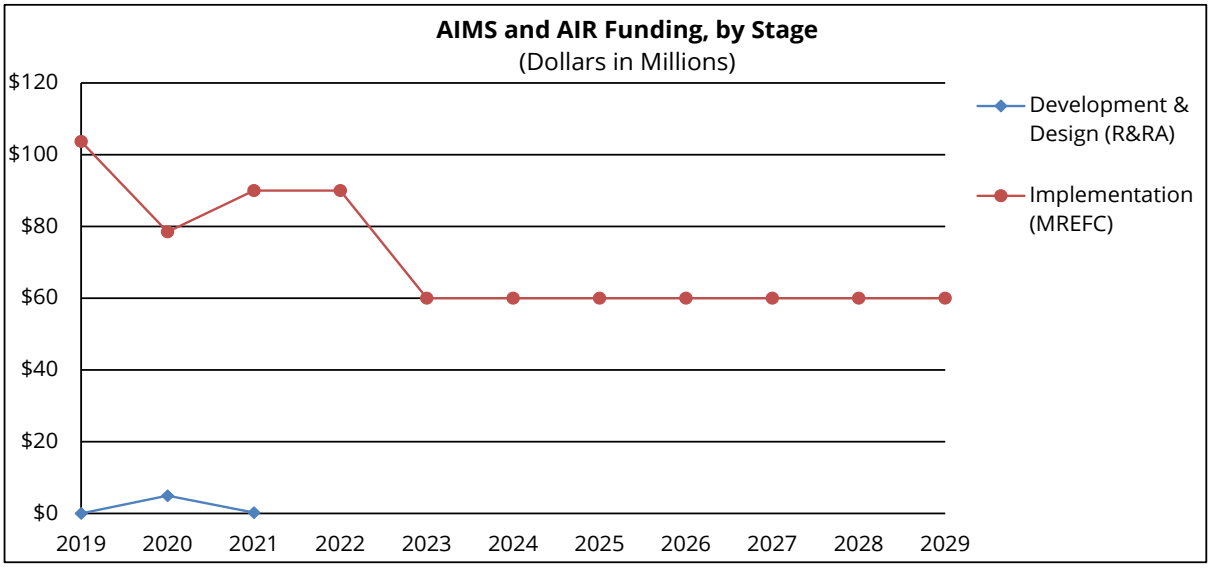
Total Funding Requirements for AIMS and AIR

(Dollars in Millions)

	Prior Years	FY 2022 Actual[1]	FY 2023 Estimate	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
R&RA:									
Development & Design	$42.46	-	-	-	-	-	-	-	-
Subtotal, R&RA	$42.46	-	-	-	-	-	-	-	-
MREFC:									
AIMS Implementation[2]	272.19	2.81	-	-	-	-	-	-	-
AIR Implementation	-	87.19	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Subtotal, MREFC	$272.19	$90.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
TOTAL REQUIREMENTS	**$314.65**	**$90.00**	**$60.00**	**$60.00**	**$60.00**	**$60.00**	**$60.00**	**$60.00**	**$60.00**

[1] Outyear estimates are for planning purposes only.

[2] Includes $150.65 million carried forward into FY 2023 for continued construction of the AIMS project. Any residual funds not needed for AIMS will be carried over into the AIR program to potentially support unfunded components of AIMS or other recapitalization priorities.



Note: The AIR program will include future development and design activities within MREFC appropriations.

Construction of the Vehicle Equipment and Operations Center and Lodging facility resumed in the FY 2023 field season under the newly revised AIMS baseline schedule. Unfunded components of the original AIMS project will be evaluated and considered for inclusion in the AIR program. As noted above, the AIR program is being managed as a portfolio of investments guided by station master plans developed with robust engagement from across the science community and with inter-agency partners. Activities are prioritized by the CIRB as conditions and requirements change, which allows the program to be responsive to the research community, proactive in mitigating risks, and well-positioned to take advantage of opportunities as they arise. The table below shows active and near-term planned investments, not in any implied order of importance.[5] These investments are multi-year projects that are in different stages of implementation. The projects and their respective stage of implementation will be updated in future budget narratives as appropriate. Scheduling of these investments will be dynamic, depending on a combination of CIRB prioritization and complex logistical considerations.

McMurdo Pier Project, $55M	Status: Execution
Mission Need: McMurdo, South Pole Station, and field camps are all reliant on resupply vessels that bring food, fuel, equipment, and materials each January. Vessels have historically offloaded at McMurdo via an ice pier in Winter Quarters Bay where materials are then trucked, traversed, or flown to their destination. The ice pier has failed three times in the past 12 years, requiring the last-minute deployment of temporary offload solutions that are costly and inefficient.	
Project Scope: This project will construct and deploy a barge-type structure that will be moored off McMurdo and can be used reliably and efficiently year after year, significantly reducing program risk.	

[5] Total project cost information is included when no longer procurement-sensitive, which is typically when the activity has been awarded for construction.

Project Status: The pier and associated bridge and mooring structures are under design, and the project is on track for completion in FY 2026.	
McMurdo Power Plant Switchgear Controls Upgrade	Status: Planning
Mission Need: Control systems manage eight generators and three wind turbines that provide power for McMurdo Station as well as New Zealand's Scott Base. The system has no redundancy, is unreliable, and has frequent outages.	
Project Scope: New software will eliminate outages related to control errors and support future generator replacements. The upgrade will enable an increase in monitoring and remote diagnostics, and will resolve information technology security vulnerabilities.	
Future USAP Data Center	Status: Planning
Mission Need: The USAP Data Center is currently housed in its own facility, which limits NSF's ability to take advantage of the efficiency and security available in the cloud environment.	
Project Scope: This project will identify a cost-effective cloud provider and migrate the USAP data center to the new service.	
South Pole Blue Building Lifting System and ARO Raise	Status: Planning
Mission Need: South Pole Station's Blue Buildings (the IceCube Lab, the Dark Sector Lab that houses the South Pole telescope, Martin A. Pomerantz Observatory (MAPO) with its attached BICEP array, and the Atmospheric Research Observatory (ARO)) are being buried in snow and without action, will become unusable.	
Project Scope: This project will lift the ARO and provide a "proof of principle" for the remaining structures. Lifting the buildings will extend their useful lifespan by 20 years and drastically reduce annual snow management workload.	
Traverse Improvements and Expansion	Status: Planning
Mission Need: The South Pole Traverse (SPoT)-2 delivers approximately 100,000 gallons of fuel to the South Pole Station each year at a fraction of the cost of airlifting the fuel. SPoT-2 modules, such as the mobile kitchen and crew quarters, were acquired in 2003, have traveled over 60,000 miles, and are failing structurally and electrically.	
Project Scope: This project refreshes the operational traverse equipment to ensure continued fuel and cargo delivery to South Pole Station and adds light duty vehicles to expand support to near-field science.	

Fleet and Equipment Refresh	Status: Planning
Mission Need: More than two-thirds of the USAP fleet, which includes cargo and passenger transport vehicles, snowmobiles, loaders, light tracked utility vehicles, and light trucks, is beyond end-of-life, in some cases by decades. Air Traffic Control and mobile communications equipment is also aging and at increasing risk of failure.	
Project Scope: This investment returns the fleet to a safe, sustainable state, allowing USAP to transition to more fuel efficient and environmentally friendly vehicles, and refreshes aging communications equipment.	
Environmental Satellite Ground System	Status: Planning
Mission Need: Environmental satellite ground systems are crucial for weather forecasting and flight planning. They are also essential for safe aviation, station operations, and science support. The current McMurdo and Palmer Station systems, Tera Scan, are at or beyond end-of-life.	
Project Status: This project will replace the McMurdo and Palmer systems, providing modern weather forecasting tools that ensure compatibility with new and future weather satellites.	
Doppler Weather Radar	Status: Planning
Mission Need: Successful and safe flight operations rely on accurate and timely weather information. McMurdo does not have any Doppler weather radar capabilities.	
Project Scope: This project will deploy Doppler weather radar to McMurdo, greatly enhancing weather forecasting capabilities which, in turn, improve the level of science support possible with USAP flight operations.	
Tactical Air Navigation Upgrade	Status: Planning
Mission Need: Tactical Air Navigation (TACAN) systems are critical for providing bearing and distance guidance and non-precision landing approach capability at McMurdo. The current TACAN is beyond end-of-life, and parts are no longer available, so refurbishment is not possible.	
Project Scope: This project will replace the McMurdo TACAN with a new, modern system.	

South Pole Critical Infrastructure Remediation	Status: Planning
Mission Need: Ice shelf movement and snow accumulation are crushing utilities supporting the vehicle maintenance facility and the safety escape hatches in the long underground utility tunnel at the South Pole Station. In addition, the fresh water well is coming to the end of its useful life.	
Project Scope: Remediates garage arches and utility tunnels being crushed by weight of snow and installs a new rodwell and outfall required for water production and waste storage, respectively.	
McMurdo Airfield Power System	Status: Planning
Mission Need: More efficient airfield equipment and facilities have lowered power demand, making the existing generators oversized, inefficient, and obsolete.	
Project Scope: This project replaces generators with more efficient units that are easier to maintain, and for which spare parts are readily available.	
Heavy Science Traverse Platform	Status: Planning
Mission Need: The existing Heavy Science Traverse, used to haul scientific drilling equipment to remote areas of Antarctica, is aging and difficult to maintain.	
Project Scope: This project will deploy new, more efficient and reliable traverse equipment in the field with expanded geographic reach, reducing reliance on costly airlift.	
McMurdo Station Utility Modernization	Status: Planning
Mission Need: Existing McMurdo Station outside plant infrastructure (e.g. potable and fire protection water requirements, electrical, heat loop, sewer, fuel services, IT communications cable and conduits) is degraded, prone to failure, costly to maintain, and will not support future facilities.	
Project Scope: This project upgrades outside plant utilities, builds a new water storage tank, and installs a fire-water booster pump.	
South Pole Satellite Communications Upgrade	Status: Planning
Mission Need: The mainland link to South Pole Station satellite communication has restricted access to the currently available and future satellites.	
Project Scope: This project replaces that ground station with a new antenna, tripling bandwidth.	
Station and Field Communication Improvements	Status: Planning
Mission Need: USAP uses a combination of mobile radios and HF radios for on-station and station-to-field communication including emergency and flight operations.	
Project Scope: This project replaces these systems to better support science and operations.	

Reviews

Conceptual Design and Preliminary Design Reviews for AIMS were passed successfully in FY 2015 and FY 2017, respectively, resulting in a National Science Board (NSB) resolution (NSB-2017-20) authorizing NSF to include AIMS in a future budget request. The AIMS Final Design Review (FDR) was conducted in October 2018. The external panel found that the project execution plan was well-developed for the FDR and recommended that the project proceed to the Construction Stage.

In addition to daily and weekly communications with the Antarctic Support Contractor's (Leidos) AIMS project management, NSF conducts a formal monthly project management review. This review covers progress described in the monthly project management report produced by Leidos. Also planned are annual Construction Reviews conducted by OPP, the Large Facilities Office, and an external panel, with the first one having occurred in November 2020. The next Construction Review is planned for the second quarter of FY 2023.

The CIRB meets on a quarterly basis to prioritize activities within the AIR Program. In FY 2023, readiness reviews for AIR activities will be conducted based on the scale and complexity of individual projects.

Risks

If the infrastructure that enables Antarctic science is not kept robust and efficient, USAP is at risk of losing science capabilities year over year as facilities, utilities, equipment, and vehicle fleet degrade.

As described above, ongoing and planned near-term activities in the AIR program will mitigate critical risks facing USAP, including some that represent single points of failure to the mission. In executing the projects, NSF has implemented a rigorous risk management approach that includes the identification of risks and mitigation strategies. Robust risk management will also be required of contractors and awardees. In all cases, NSF holds the risk of cost and schedule increases that are beyond the control of the contractor or awardee, including events such as pandemics, unpredictably severe weather, icebreaker and supply vessel availability, and macroeconomic changes.

COVID-19 and inflation impact on the construction market, labor force, supply chains, travel restrictions, and safety protocols present the greatest near-term risks to AIMS and AIR due to the size and complexity of these programs.

HIGH LUMINOSITY-LARGE HADRON COLLIDER UPGRADE (HL-LHC) $38,000,000

Appropriated and Requested MREFC Funds for the
High Luminosity-Large Hadron Collider Upgrade
(Dollars in Millions)

	FY 2020	FY 2021	FY 2022	FY 2023 Estimate	FY 2024 Request	Total Project
Previous Authorized Total Project Cost	$33.00	$33.00	$36.00	$33.00	$18.00	$153.00
Preliminary Est. of Future COVID-19 Impact[1]	-	-	-	-	20.00	20.00
Estimate prior to Rebaseline	**$33.00**	**$33.00**	**$36.00**	**$33.00**	**$38.00**	**$173.00**

[1] COVID-19 impact estimates are preliminary and not yet fully substantiated. Ongoing schedule and cost impacts will lead to revisions of the current funding plan through a re-baseline process.

Brief Description

The Large Hadron Collider is the world's largest and highest-energy particle accelerator. Located near Geneva, Switzerland and operated by the European Organization for Nuclear Research (CERN), the LHC is designed to accelerate and collide counter-propagating bunches of protons at a total energy of up to 14 TeV (one TeV=10^{12} electron volts). Physicists study the debris from these collisions to learn about the elementary particles and fundamental forces that shape the universe. U.S. involvement in the LHC is jointly supported and overseen by NSF and the Department of Energy (DOE) and is primarily focused on supporting research, upgrades, and operations and maintenance (O&M) at two general purpose detectors: "A Toroidal LHC ApparatuS" (ATLAS) and "Compact Muon Solenoid" (CMS). HL-LHC is an enhancement to the accelerator that will increase the proton collision rate (known as "luminosity") by a factor of about 5 to 7. The upgrades funded by this request are modifications to the ATLAS and CMS detectors that will enable them to operate at the higher collision rate and with greater measurement precision. NSF's HL-LHC upgrade program represents about seven percent of the global high luminosity upgrade effort at the LHC, which is being supported by 45 funding agencies internationally.[1]

NSF's FY 2024 Request for HL-LHC is $38.0 million to continue support for ongoing component upgrades of the ATLAS and CMS detectors. The baseline $18.0 million of the FY 2024 Request amount supports the current NSB-authorized Total Project Cost (TPC) of $153.0 million. For planning purposes, a preliminary estimate of an additional $20.0 million is incorporated into the FY 2024 funding profile (which would raise the TPC to $173.0 million) to address the direct and indirect impacts on the project from COVID-19, historically high inflation, supply-chain delays, and the Russian attack on Ukraine (both Russia and Ukraine participate in LHC research and detector upgrade activities).

NSF is working closely with the project management of the ATLAS and CMS detector upgrade

[1]U.S. DOE is among the other agencies supporting the overall HL upgrade effort, including the upgrade to the accelerator, while NSF supports only the upgrades to the ATLAS and CMS detectors. The scope of DOE-supported activities is independent of the NSF-supported scope, though some links exist at the level of university-based efforts. NSF and DOE coordinated development and design efforts in preparation for construction of the HL upgrades and will continue joint oversight of the U.S. components of the ATLAS and CMS O&M programs through the HL upgrades and subsequent operations; see the Governance Structure and Partnerships section below for details.

programs to more fully understand these impacts on the overall costs and schedules to complete planned activities. The current estimates will be refined through a re-baselining of the HL-LHC detector upgrade program that NSF plans to conduct in the spring of 2023, when it is anticipated that there will be a stable and quantifiable understanding of the consequences of these impacts on the NSF-funded scope. The re-baselining is expected to confirm and quantify the need for additional MREFC funding above the current authorized TPC of $153.0 million. If an increase to the TPC is authorized by NSB, NSF plans to obligate additional budget to each of the detector upgrade efforts in late FY 2024 and early FY 2025 to remediate these impacts. See the Baseline History section below for more details on the approval timeline and refer to the Project Status section for a summary of the current understanding of COVID-19 impacts.

Baseline History

Following an agreement among NSF, DOE, and CERN ("Experiments Protocol I"), signed in December 1997, NSF began support for construction of ATLAS and CMS detector elements and software development in 1998. NSF has subsequently supported ongoing O&M,[2] as well as a previous smaller-scale upgrade to each detector. Since 2011, U.S. funding for ATLAS and CMS O&M has included investments in advanced R&D for investigations into detector modifications that enable the detectors to function at much higher collision rates in conjunction with an upgrade to increase the luminosity of the LHC. The ATLAS and CMS groups, consisting of researchers from all participating countries, each developed scoping documents describing their scientific goals and the technical paths forward for operation in the challenging HL-LHC environment.

In 2014, the Particle Physics Project Prioritization Panel (P5), a subcommittee of the High Energy Physics Advisory Panel that advises NSF and DOE, recommended U.S. participation in the detector upgrades. In fall 2014, MPS charged a subcommittee of its Advisory Committee (MPS AC) to advise on an appropriate response. The subcommittee, with MPS AC endorsement, recommended that NSF provide construction funding at the major facility level to enable meaningful participation by NSF-supported scientists in the HL-LHC research program. An estimated $150.0 million funding target was defined by NSF in consultation with the MPS AC.

In July 2018, after completing the requirements of the major facility Preliminary Design phase, NSB authorized the NSF Director to include construction of the High Luminosity upgrades to the ATLAS and CMS detectors in a future Budget Request. Funding to begin construction was provided in the FY 2020 MREFC appropriation, and the NSF Director obtained the NSB's authorization, in February 2020, to begin construction in FY 2020 with separate construction awards to Columbia and Cornell Universities (for ATLAS and CMS, respectively) totaling $153.0 million (adjusted upward by $3.0 million in the Final Design Review process).

Project Status

Each project is currently (as of December 2022) more than one-third complete. Due to the impacts of the COVID-19 pandemic and the other factors mentioned above, both projects are well behind their original schedules.

[2] Oversight of the U.S. component of the ATLAS and CMS O&M programs is jointly conducted by NSF and DOE. See the Governance Structure and Partnerships section below.

Summary of COVID-19 Impacts

The pandemic has resulted in schedule delays and cost increases. Early in the pandemic, universities closed laboratories and workshops where fabrication activities had been planned, although these were later re-opened after instituting health safety restrictions that reduced labor efficiency. COVID-19 also slowed the work undertaken by CERN and foreign partners to develop several custom application-specific integrated circuits (ASICs) planned for use in many subsystems of the ATLAS and CMS detectors, delaying scheduled activities supported by NSF and many other funding agencies. The pandemic also resulted in the temporary closure of radiation test facilities used to evaluate the radiation hardness of custom sensors and integrated circuit prototypes. It impacted industry as well, slowing vendor deliveries of some highly specialized materials and electronic components needed for the detector upgrades.

Relatively small cost impacts have been realized so far (approximately $2 million) because many initial project activities, coinciding with the early stage of the pandemic, involved detailed production design work, procurements, and software development activities that could be accomplished through remote telework. Normal activities have now resumed in the labs and workshops at the U.S. universities involved in the NSF-supported scope. Impacts from supply chain delays and exceptional inflation still pose risks, and these impacts are becoming better understood as vendors provide bids and delivery schedules for production quantities of key components.

In January 2022, reacting to pandemic impacts on the overall upgrade schedule and the individual funding agencies participating in the upgrades, CERN announced a one-year delay to the start of installation of the HL-LHC accelerator and detector components, moving the date from January 2025 to January 2026. CERN additionally announced an extension in the installation period to three full years – through the end of calendar year 2028 (rather than the two and one-half years that had been previously planned) to allow these activities to be completed. In June 2022, the CERN Council announced its intent to end cooperation with Belarus and Russia (in June and December 2024, respectively) in response to Russia's ongoing aggression against Ukraine.

ATLAS and CMS management teams are revising their detector upgrade project plans to account for impacts of the pandemic and the other factors mentioned above in preparation for NSF's spring 2023 re-baselining review. These revisions will include the additional pandemic-related costs already realized, and they will quantitatively forecast all impacts on remaining tasks that must be accomplished to deliver each of the upgraded detector subsystems. The ATLAS and CMS teams will revise their construction plans to update factors such as labor efficiency, costs to establish and maintain safe working environments, escalation costs arising from schedule delays, revised material and labor costs, assumption of a proportional share of the undelivered Russian/Belarusian scope, and contingency costs arising from re-estimation of future risks due to COVID-19. For planning purposes, NSF has incorporated an estimate of $20.0 million in the FY 2024 Request to account for COVID-related needs. If additional funding is required after the full re-baseline analysis, it will be incorporated into the FY 2025 request.

Meeting Intellectual Community Needs

Initial operation of the LHC, and the ATLAS and CMS detectors, enabled the discovery of the Higgs boson in 2012, leading to the 2013 Nobel Prize in Physics. The Higgs mechanism explains how fundamental particles acquire mass. Despite this historic accomplishment, the ATLAS and CMS

experiments have only scratched the surface of the ultimate physics potential of the LHC.

There are many open fundamental questions in particle physics. Three key science questions that the HL-LHC program will address are:

- What are the properties of the Higgs boson?
- Are there new particles and interactions beyond those predicted by the Standard Model?
- What is the nature of dark matter?

To answer these questions, researchers must compare theoretical predictions with observations of various rare processes, such as those involving the Higgs boson, that could be sensitive indicators of new physical phenomena. Discovering meaningful departures from theoretical predictions will require high precision measurements and the collection of a data sample more than two orders of magnitude larger than the one used for the Higgs discovery in 2012. To accomplish this, CERN is upgrading the accelerator, which will be renamed the High Luminosity-LHC, to deliver the high intensity proton beams required. The HL-LHC is planned to commence ten years of operation in 2028. During that time, it is expected to produce more than 10 times the data collected by LHC operation through 2025 (a hundred-fold increase relative to the data set that was used to confirm the 2012 Higgs discovery).

In parallel with the accelerator upgrade, NSF is funding the construction of critical components of the ATLAS and CMS detectors that will allow them to record and analyze the torrent of data to be produced. NSF contributions primarily fund radiation-hard electronics that increase the spatial granularity of calorimeter and muon detectors, expansion of the charged-particle tracking close to the beam direction in the CMS detector, and major improvements to the fast-decision-making electronics that trigger each detector to select and record interesting, rare events.

Currently, more than 1,200 U.S. researchers participate in the ATLAS and CMS collaborations, including more than 100 post-doctoral fellows and more than 400 students, of whom about half are undergraduates. The U.S. researchers comprise about 20 percent of the total membership of the ATLAS and CMS collaborations. NSF supports about 20 percent of the U.S. ATLAS and CMS contingents.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is handled by a program officer in the Division of Physics (PHY). Cross-foundation coordination is provided by an Integrated Project Team that includes staff from MPS, BFA, EDU, OISE, the Office of the Director, the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office (LFO) and the Division of Acquisition and Cooperative Support provide advice to program staff and assist with agency oversight and assurance. The MPS Facilities Team and NSF's Chief Officer for Research Facilities also provide high-level guidance and oversight support for the project. The NSF program officer works closely with PHY colleagues overseeing the Experimental Particle Physics research program at NSF, and with counterparts in the DOE Office of High Energy Physics. Interagency coordination is accomplished through a Joint Oversight Group (JOG), which meets at least semi-annually. The framework for joint DOE/NSF oversight of the U.S.-led portion of the international ATLAS and CMS collaborations has a successful history spanning more than two decades. It is based on an interagency Memorandum of Understanding (MOU) that

was initially implemented in December 1999 and that was replaced by a new MOU in March 2018 to encompass HL-LHC activities.

External Governance Structure

NSF-funded principal investigators at Columbia University and Cornell University are responsible for managing and accomplishing the NSF-designated scope. NSF- and DOE-funded activities, which together form the U.S. collaboration for ATLAS and CMS, are coordinated through the JOG as described above. The U.S. collaborations coordinate with the international ATLAS and CMS project leadership to accomplish the entire upgrade program.

The CERN LHC Resources Review Boards (separate boards for ATLAS and CMS) are composed of representatives from each participating funding agency. The Boards monitor and oversee resource-related matters as defined by the framework for participation in each experiment. NSF is a full member of these LHC Resources Review Boards. The Boards meet semi-annually to oversee and approve all LHC upgrade plans and major decisions at the international level.

Partnerships and Other Funding Sources

More than 45 funding agencies worldwide are contributing various components of the upgraded detectors. NSF investments in the upgrades enable university-based U.S. scientists and students to participate in the HL-LHC experimental program, which currently has about 7,000 participants worldwide. NSF is working closely with DOE to coordinate construction activities and to jointly oversee each detector's operation.

In May 2015, DOE, NSF, and CERN executed a cooperation agreement concerning scientific and technical cooperation in nuclear and particle physics. The cooperation agreement established the framework under which DOE, NSF, and their awardees, as well as DOE national laboratories, participate in the particle physics programs in the international ATLAS and CMS detector collaborations (under the auspices of CERN) in the era of the HL-LHC. Subject to availability of appropriated funds, NSF's total contributions to the HL-LHC detector upgrade program are specified and incorporated under separate implementing arrangements in the form of addenda to the 2015 cooperation agreement.

Cost and Schedule

Commencement of NSF-funded construction in April 2020 was considered critical to enable recipient U.S. universities to undertake timely fabrication and delivery of components to CERN to meet the international integration schedule. A significant delay could have resulted in the transfer of NSF-funded scope to other international partners, resulting in lost opportunities for U.S. scientists.

The major facility construction project will be completed when the NSF-funded components for both detectors are delivered and verified at CERN to be in good working order. NSF will support the subsequent installation, integration, and system testing of the NSF-funded components at CERN through awards to U.S. ATLAS and U.S. CMS collaborations for detector O&M. This work is currently planned to occur during CY 2026-2028. NSF's share of installation and commissioning costs was estimated before the pandemic outbreak at about $5.0 million per detector and reconfirmed in reviews NSF held in July 2021. The annual O&M cost is forecast to remain constant during and following the HL-LHC Detector Upgrade installation.

Total Funding Requirements for HL-LHC Upgrade

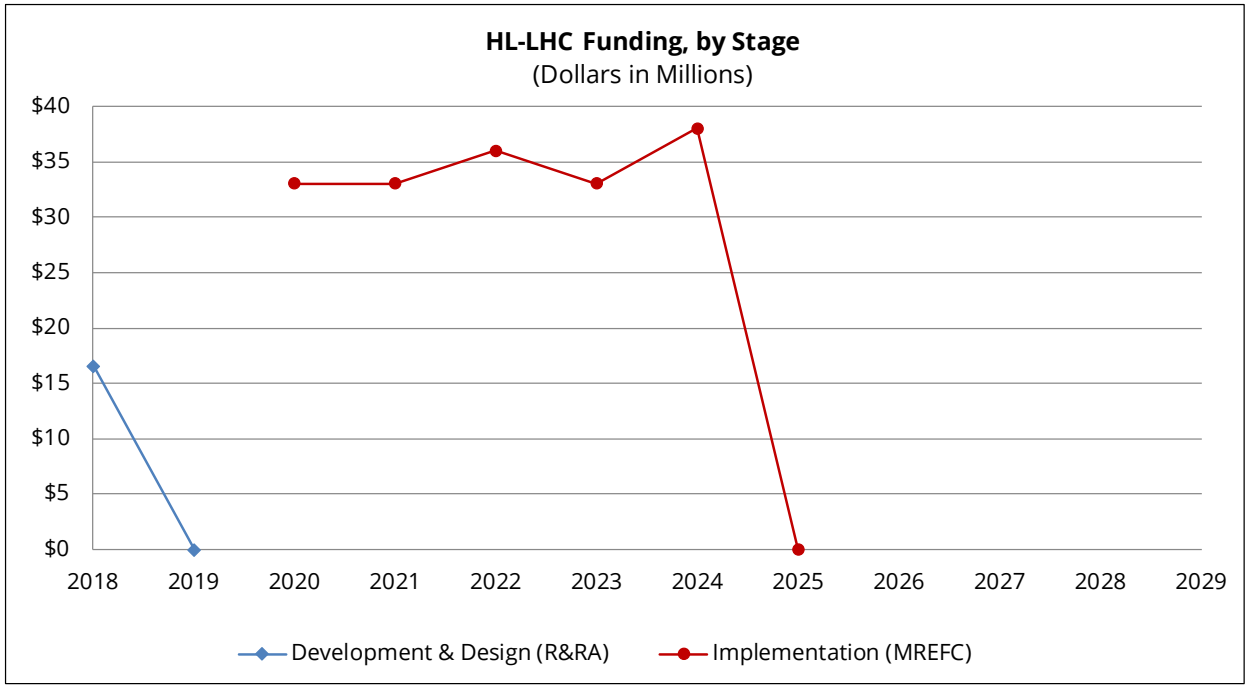
(Dollars in Millions)

	Prior Years	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
R&RA:									
Development & Design	$24.31	-	-	-	-	-	-	-	-
Operations & Maintenance[2]		-	-	-	TBD	TBD	TBD	TBD	TBD
Subtotal, R&RA	$24.31	-	-	-	-	-	-	-	-
MREFC:									
Implementation[3]	66.00	36.00	33.00	38.00	-	-	-	-	-
Subtotal, MREFC	$66.00	$36.00	$33.00	$38.00	-	-	-	-	-
TOTAL REQUIREMENTS	**$90.31**	**$36.00**	**$33.00**	**$38.00**	**-**	**-**	**-**	**-**	**-**

[1] Outyear estimates are for planning purposes only. The current cooperative agreements end in December 2026 (CMS) and January 2027 (ATLAS) - see LHC request in the Major Facilities section.

[2] FY 2025 and beyond are TBD because COVID-19-related delays are increasingly likely to move the operations phase of HL-LHC past this reporting window.

[3] COVID-19 impacts are preliminary. An estimate of an additional $20.0 million in COVID-related funding need is incorporated in the FY 2024 Request for planning purposes. Schedule and cost impacts will lead to revisions of the funding plan.



Future Operations Costs

An additional agreement among NSF, DOE, and CERN ("Experiments Protocol II"), signed in December 2015, follows on from the more general cooperation agreement signed in May 2015; it documents the responsibilities of U.S. participants to provide normal O&M of detector subsystems and components provided by NSF and DOE. Future MOUs with CERN will describe the distribution of tasks and other responsibilities for all participating institutions, including those supported by NSF, as well as the organizational, managerial, and financial guidelines to be followed by each detector collaboration.

NSF anticipates providing approximately three percent of the total operations cost of the ATLAS and CMS detectors during HL-LHC operation, as it does today. This proportion is based on the number of NSF-supported scientists in each collaboration. NSF's external reviews of the impacts of the HL upgrades on future operating costs indicated that these projections are reasonable and are based on realistic assumptions. These projections are regularly revisited during the period of construction to incorporate evolving understanding of the impacts of the pandemic and other events on future operation.

A well-orchestrated global effort is underway, progressing in parallel with the HL-LHC detector upgrades, to meet the challenges of computing in the HL era. ATLAS and CMS are coordinating their efforts within this framework to seek common solutions in areas of mutual interest. The coordination framework extends across the U.S. ATLAS and U.S. CMS collaborations, the U.S. funding agencies, other national funding agencies, and CERN. In July 2021, NSF conducted reviews of the software and computing R&D efforts that are underway to develop tools and methods that will satisfy future computing needs during HL-LHC operation. The reviewers expressed confidence that the multiple software research programs now underway to address these challenges are likely to provide affordable solutions within the flat computing budgets that are planned (by NSF, DOE, and funding agencies in other countries). Many of the R&D tasks now underway are promising, and only a subset needs to be successful to meet the needs of the HL operating program.

Reviews

- Conceptual Design Reviews (2016), Preliminary Design Reviews (2017-2018) and Final Design Reviews (2019) with external review panels were carried out in accordance with the requirements of NSF's Major Facilities Guide, with panel reports favorable to the continuation of the program as designs matured.
- Review of the O&M Plans of ATLAS and CMS for CY 2017-2021 (whose scope includes development and design activities for the detector upgrades) were held in July 2016.
- CERN international committee reviews: Major subsystems of the combined international effort were scientifically and technically reviewed by the CERN LHC Committee (LHCC), an international committee of technical experts, followed by a cost and schedule review by the CERN Upgrade Cost Group, an international committee of technical and financial experts that reported to the LHCC (July 2017-April 2018).
- Full Life-cycle Cost Reviews: NSF held reviews of the cost impacts of the HL upgrades on the LHC operations program in October 2019.
- NSF held external reviews of ATLAS and CMS installation plans and software and computing R&D projects in July 2021 to assess the stability of the planned scope, the forecast budget needs and schedule requirements, and the risk projections for these activities. The reviews indicated that these activities are well-planned and appropriately budgeted. Impacts from possible future revisions by CERN to the LHC run schedule are estimated to have minimal budget impact.
- Reviews of ATLAS and CMS HL upgrade activities took place in August 2021 to examine the current technical, financial, schedule, and risk status of each project and the current assessments of total pandemic impacts.
- At the end of January 2022, NSF and DOE conducted joint reviews of ATLAS and CMS Operation. The reviews included an assessment of the status and plans for software and computing R&D that will facilitate efficient and cost-effective processing of HL-LHC data. The reviews provided assurance that ATLAS and CMS will have in place the data processing capabilities needed to

analyze HL-LHC data.

- Rebaselining reviews of the CMS and ATLAS detector upgrades will be held in March and April 2023, respectively. The external reviews and NSF's Internal Cost Assessment of the budget and schedule changes requested will be used to confirm MREFC funding needed in FY 2024 and any potential funding needs in FY 2025.

Risks

Technical Risk

Technical designs were sufficiently mature at the start of construction to credibly support estimates of the costs to complete construction. Cost and schedule impacts due to technical risks are credibly bounded. There are multiple alternatives for dealing with the known production uncertainties, although the unanticipated impacts of the pandemic have introduced supply chain issues and substantially delayed access to radiation testing facilities needed to verify design performance. Progress to date, such as completion and testing of prototypes, pre-production fabrication of limited quantities of detector components, and system integration tests have retired many technical risks.

Deployment Risk

The MREFC-supported construction projects conclude with delivery and verification of subcomponent operability at CERN. CERN has overall responsibility for coordinating the assembly, integration, and commissioning of the upgraded detectors, integrating the contributions from more than 40 different countries to each detector. While a slip in the CERN schedule for installation will delay scientific research, the total project cost of the NSF-funded construction projects is not anticipated to increase due to the expanded time interval between delivery of the NSF-funded elements to CERN and CERN's recently revised start of installation (which NSF supports through its funding of ATLAS and CMS O&M programs). If pandemic impacts are prolonged, this could result in additional changes to installation and commissioning requirements and methods, but external reviews confirmed that overall cost impacts due to potential schedule delays are minor. If there is another significant delay in the start of installation, or a prolonged installation period, NSF will trade off installation support against O&M support to remain within the flat overall annual O&M budget profile planned.

Management Risk

The FDRs established that the management risk was low; the ATLAS and CMS management teams are well-qualified and well-prepared to undertake construction activities, with appropriate organizational structures and delegations of responsibility. The review committees reported that each team's development of cost and schedule estimates was based on sound (pre-pandemic) assumptions and methods that are consistent with best practices defined by the Government Accountability Office in the Cost Estimating and Schedule Assessment guides. The FDR panels also expressed confidence that each upgrade could be accomplished within its estimated TPC, after adjusting the CMS estimate upward by $3.0 million to cover possible increased costs related to critical components. The ATLAS and CMS Project Execution Plans included detailed (pre-COVID) risk management considerations and mitigation strategies. Each project maintains a risk register that is regularly updated (and which includes risks resulting from the pandemic). The management teams are stable. Business Systems Reviews conducted by NSF in late 2022 confirmed that the financial and business management practices used by Columbia and Cornell Universities to administer these awards align with Federal regulations and meet compliance requirements.

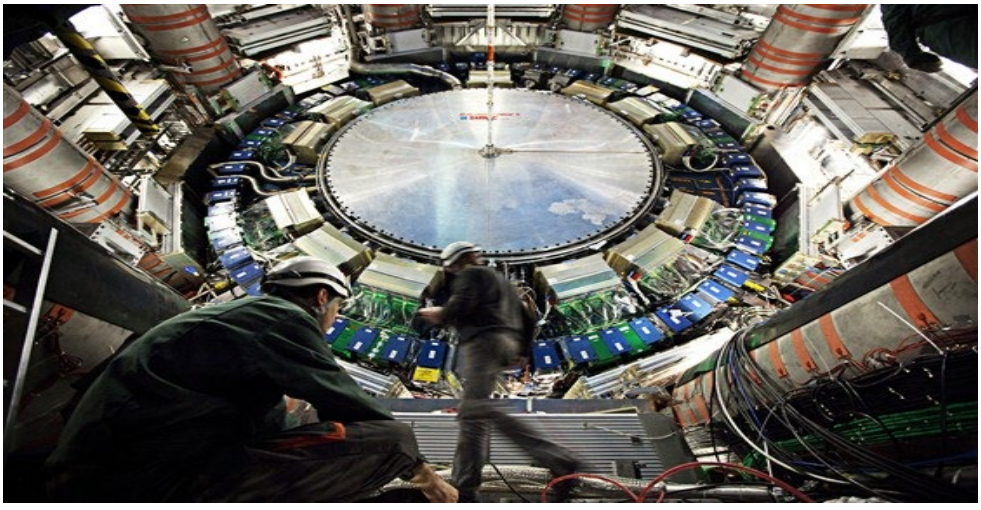
Partnership Risk

The NSF scope for the detector upgrades relies on the successful and timely completion of testing by international partners of some key components, such as radiation-tolerant custom electronic circuits that are used throughout both detectors in many HL upgrade applications. That activity is now nearly complete, which will enable a confident evaluation at the Spring 2023 rebaselining reviews. COVID-19 impacts on international partners, as well as impacts on foreign suppliers of components for the NSF-funded scope, added new schedule and cost risks to those considered when construction budgets were developed. Revised schedules and cost estimates and re-evaluation of remaining risks will be assessed during the Spring 2023 rebaselining reviews.

A further partnership risk arises from possible disruption of the detector fabrication activities that rely, in part, on DOE and NSF research grants to universities. Faculty, post-docs, and graduate students participate in the management, testing, characterization, and software development of detector components fabricated by engineers and technicians. While the engineering and technical labor is funded through the MREFC awards, the faculty, post-docs, and graduate students are supported by research grants from DOE and NSF to universities and colleges. Risks and contingency budgets were refined through the FDR process to assure NSF that partnership risks could be confidently addressed. These pre-COVID assessments did not consider the possibility that the pandemic would close some university laboratories and shop facilities and restrict the level of student and post-doctoral fellow participation in hands-on activities associated with testing and characterizing detector components. As most of the fabrication of production quantities of various detector components occurs later in the construction schedule, only minor impacts from this risk have been realized so far, and all participating university laboratories and shop facilities in the U.S. are now open.

Disposal Costs

CERN's policy is to dispose of all detector components when they are no longer used in the detectors. NSF will be responsible only for covering its share of the demolition costs to remove each detector from its underground operating location and transport it to the surface for disposal by CERN. At the Full Life-Cycle Cost Reviews each detector collaboration estimated these costs at approximately $1-2 million (not escalated).



View of the ATLAS detector. *Credit: CERN.*

LEADERSHIP-CLASS COMPUTING FACILITY (LCCF) **$93,000,000**

Appropriated and Requested MREFC Funds for the Leadership-Class Computing Facility[1]

(Dollars in Millions)

FY 2024 Request	FY 2025 Estimate	FY 2026 Estimate	FY 2027 Estimate
$93.00	$247.00	$147.00	$33.00

[1] Internal NSF cost analysis indicates the Total Project Cost would range from $520.0 million to $620.0 million depending on the acquisition strategy used for the data center. The acquisition strategy will be determined during the Final Design Phase and prior to award, if authorized. Future budget requests will be modified accordingly.

Brief Description

Computer simulation, together with artificial intelligence (AI) methods and data analytics, is critical to enabling transformational science and engineering (S&E) research. From understanding the origin and evolution of our universe to exploring atomic-scale biomolecular processes, computational methods are now an integral part of almost all curiosity-driven, use-inspired, and translational S&E research. The LCCF, led by the Texas Advanced Computing Center (TACC) at the University of Texas at Austin, is envisioned as a distributed facility that will provide unique computational and data analytics capabilities, as well as critical software and services, for the nation's S&E research community to enable discoveries that would not be possible otherwise. Furthermore, the project will deploy a comprehensive range of education and outreach activities that will expand and nurture our nation's future S&E workforce in data and computational science.

The LCCF will integrate multiple systems located at geographically distributed data processing and discovery sites. The LCCF processing capabilities will be anchored by a computing system called *Horizon,* which will substantially increase the computational and data analytics capacity of the current NSF leadership-class computing system, *Frontera*. The LCCF will include four Distributed Science Centers (DSCs), which will be located at the Atlanta University Center Consortium (AUCC), the National Center for Supercomputing Applications (NCSA) located at the University of Illinois Urbana-Champaign, the Pittsburgh Supercomputing Center (PSC), and the San Diego Supercomputer Center (SDSC). These DSCs are designed to leverage expertise across the broader cyberinfrastructure (CI) ecosystem and provide critical edge computing services to the LCCF user community. The partnership with AUCC will enable engagement with four Historically Black Colleges and Universities (HBCUs) to provide workforce pathways for HBCU students into leadership computing and computational data science. The partnership with NCSA will explore and provide new processor technologies for Artificial Intelligence (AI). The partnership with PSC will provide data intensive computing and data mirrors for published archives. Finally, the partnership with SDSC will provide testbeds focused on supporting Machine Learning (ML) and instrument data analytics in scientific workflows, and methods to democratize access to LCCF.

In addition to supporting large-scale simulations, the LCCF will also support new usage modes such as interactive computing required by scientific tasks that involve human-in-the-loop processing, as well as urgent computing for emergency response scenarios that will need immediate access to

computing resources and real-time data. The LCCF will also support the full scientific data lifecycle, which is critical to the modern S&E discovery processes and to unleashing the potential of rapid advancements in Machine Learning and AI. The extensive LCCF Education and Public Outreach (EPO) effort has the goals of expanding the learning and workforce pipeline and broadening participation in research computing, especially from underrepresented groups, to advance Diversity, Equity, and Inclusion. A key component of the LCCF EPO activities will be a Visitor Center that will include virtual and physical exhibits, along with multiple pilot activities that will be designed to engage students, teachers, and the broader public across the nation.

Baseline History

In Fiscal Year 2017, NSF released solicitation NSF 17-558 (*Towards a Leadership-Class Computing Facility - Phase 1*)[1] to support the acquisition of a Phase 1 leadership-class computing system and to initiate the planning process for a future Phase 2 leadership-class computing facility. After a rigorous merit review of the submitted proposals, NSF requested that the National Science Board (NSB) authorize an award to TACC. In July 2018, NSB authorized the acquisition of the *Frontera* system, the first acquisition in the two-phased process, and funding to advance the planning of a Phase 2 LCCF. As noted in NSF 17-558, and in response to the recommendations set forth in the report *Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020*[2], the goal of the LCCF Phase 2 planning is the design of a major facility that will support all S&E research that requires the largest and most computationally intensive capabilities to enable discoveries that would otherwise not be possible.

The Major Facilities Design Stage, as defined in the NSF Research Infrastructure Guide[3], consists of three phases – Conceptual Design, Preliminary Design, and Final Design. In July 2019, the LCCF began the Conceptual Design Phase following approval by the NSF Director to formally enter the Design Stage. The Conceptual Design Review (CDR) was conducted in FY 2020 by an external panel of experts to evaluate the proposed site-independent design of the LCCF. A successful outcome from the CDR resulted in the project entering the Preliminary Design Phase in September 2020.

Following extensive Preliminary Design Phase planning activities, the project successfully completed the Preliminary Design Review (PDR) in January 2022. At PDR, the project was judged by an external panel of experts to have made appropriate progress in clearly articulating a bottom-up cost estimate and a near-final project definition, as well as sufficiently mature risk analysis to allow determination of the risk-adjusted Total Project Cost (TPC) and construction duration for establishing a budget request to Congress. A successful outcome from the PDR resulted in the project entering the Final Design Phase in August 2022.

[1] *NSF 17-558, Towards a Leadership-Class Computing Facility - Phase 1*, www.nsf.gov/pubs/2017/nsf17558/nsf17558.htm

[2] Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020, www.nationalacademies.org/our-work/future-directions-for-nsf-advanced-computing-infrastructure-to-support-us-science-in-2017-2020

[3] NSF Research Infrastructure Guide, www.nsf.gov/pubs/2021/nsf21107/nsf21107.pdf

Project Status

The LCCF project is currently in the Final Design Phase. In this phase, the project will finalize the details in the project execution plan to ensure it is ready to enter the Construction Stage. The project's current activities include refining the technical requirements, completing the implementation of the Project Management Control System, resolving negotiations for all external contracts, and incorporating any events, conditions, or risks previously unforeseen at the PDR into the final plan.

Meeting Intellectual Community Needs

The scientific requirements for the LCCF are defined by the needs of the S&E community. These requirements include the need to expand computation and data analytics capabilities, as well as the size and diversity of the workforce capable of using these capabilities. LCCF requirements also include the need to be agile and adapt to rapidly changing technology, new application formulations, and requirements, as well as new paradigms of computation-based research. Furthermore, the LCCF will need to enhance the broader high-performance computing ecosystem by providing unique resources and expertise at our nation's Institutions of Higher Education that complement other investments in the federal government and in industry.

The LCCF scientific requirements were determined through a broad set of engagements with the S&E community. These included: distillation from a wide variety of scientific community reports; analysis of usage patterns on leadership computing systems across government; feedback from project-organized planning meetings with the research community; discussions under non-disclosure agreements with industry vendors concerning technology roadmaps; technical evaluation of advanced system prototypes; and direct conversations and interviews with scientists and engineers.

During the Preliminary Design Phase, the LCCF augmented its science requirements gathering activities by selecting twenty-one Characteristic Science Application (CSA) teams as partners with the project. The CSA partners represent applications across a broad range of S&E domains and were selected to enable the development of a suite of science drivers that will be used to verify and validate the facility's effectiveness. The CSA partners will also provide requirements to inform design decisions and enable the project to acquire experience and expertise in coding/performance-tuning enhancements in preparation for facility operations.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight of LCCF is provided by a Program Officer in the CISE Office of Advanced Cyberinfrastructure (OAC), working cooperatively with other NSF staff through an Integrated Project Team (IPT). The LCCF IPT includes members from OAC leadership, Large Facilities Office (LFO), Office of the General Counsel (OGC), Budget Division, Division of Acquisition and Cooperative Support, and Office of the Director. In addition, LFO staff provides advice to OAC and assists with agency oversight and assurance. CISE leadership and NSF's Chief Officer for Research Facilities provide additional high-level guidance and oversight to the project.

External Governance Structure

The LCCF Senior Management Team consists of the LCCF Project Director (PD), the Project Manager

(PM), and the Deputy Project Manager (DPM). This group is responsible for the day-to-day management of the LCCF project. The PD serves as the primary interface for the project with external oversight from NSF. The Project Management office is headed by the PM and DPM, who report to the PD. The PM has line responsibility for operations, reporting, and process management within the project, with support from the DPM. The PD is advised by two groups: the Technology Advisory Board and the Science Advisory Board. Each board consists of members who are leaders in their fields and represent cyberinfrastructure providers and experts (the Technology board) and stakeholders from the community of scientists who will be the ultimate customers of the LCCF (the Science board).

Partnerships and Other Funding Sources

The LCCF project includes partnerships with over twenty-six academic institutions that will contribute to the design, validation, and eventual operations of the LCCF. Academic partners include various institution types, including Minority Serving Institutions and Historically Black Colleges and Universities. The project also has extensive industry partnerships in various high-tech economic sectors, such as semiconductor design, computing hardware, software, and data center colocation.

Cost and Schedule

Pending NSF and NSB authorization for a Construction Stage award after successful completion of a future Final Design Review (FDR), and appropriation of sufficient funds by Congress, LCCF construction will begin in FY 2024. The schedule proposed at PDR has a duration of 34 months, providing facility acceptance in FY 2027.

Total Funding Requirements for LCCF

(Dollars in Millions)

	Prior Years	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
R&RA:									
Development & Design	$12.50	$3.50	-	-	-	-	-	-	-
Operations & Maintenance		-	-	-			40.00	40.00	40.00
Subtotal, R&RA	$12.50	$3.50	-	-	-	-	$40.00	$40.00	$40.00
MREFC: Implementation[2]	-	-	-	93.00	247.00	147.00	33.00		
Subtotal, MREFC	-	-	-	$93.00	$247.00	$147.00	$33.00	-	-
TOTAL REQUIREMENTS	**$12.50**	**$3.50**	**-**	**$93.00**	**$247.00**	**$147.00**	**$73.00**	**$40.00**	**$40.00**

[1] Outyear numbers are for planning purposes only.

[2] Internal NSF cost analysis indicates the Total Project Cost would range from $520.0 million to $620.0 million depending on the acquisition strategy used for the data center. The acquisition strategy will be determined during the Final Design Phase and prior to award, if authorized. Future budget requests will be modified accordingly.

Future Operations Costs

Contingent on the availability of funds, NSF plans to support LCCF operations and maintenance for an initial five years with a possibility of renewal for another five years. The current estimate is that LCCF operations will cost $40.0 million annually. NSF support for LCCF beyond 10 years, and possible re-competition of the operations and maintenance award, will be informed by a planned future study by the National Academies of Sciences, Engineering, and Medicine or other similar reports by community-based bodies and will follow internal NSF procedures for renewal, competition, and disposition.

Reviews

Technical Reviews

The LCCF project has been technically reviewed multiple times during the Design Stage by external committees of experts. These include stage gate reviews at CDR and PDR in FYs 2020 and 2022, respectively. The LCCF CSA program was also reviewed by a panel of external experts in FY 2021. The LCCF FDR is planned for Spring 2023.

Management, Cost, and Schedule Reviews

In accordance with NSF's No Cost Overrun Policy, the agency has developed a risk adjusted TPC estimate post-PDR (based on known risks) to inform the budget request to Congress. Using the TACC proposal as the basis for the cost analysis, BFA employed a series of independent cost estimate reviews to inform NSF's post-PDR cost analysis. These included an independent cost estimate in accordance with U.S. Government Accountability Office good practices, conducted by an external contractor for appropriate project components, BFA's internal Cost Analysis and Pre-award Branch for other elements of cost, and LFO for assessments of budget contingency and schedule. This information was reconciled against the original proposed budget from TACC in determining the recommended value for potential budget inclusion in a future budget request.

Risks

Technical

The LCCF project deploys state-of-the-art technologies and services for the Nation's S&E research community. Several risks related to the readiness and reliability of the future deployed systems and services are included in the LCCF risk register. The LCCF CSA partnerships will be key in monitoring and managing these risks as the CSA teams will be the early users of the facility and will help identify and remedy issues as they arise. Cost and schedule contingencies have also been factored into the plan to mitigate these risks. In addition, a scope management plan provides options to mitigate cost or schedule overruns by eliminating project scope if necessary. LCCF's scope management plan is arranged so that any decision to descope can be made as late as possible in the project and with minimal impact on the science goals.

Site

The LCCF project proposes to use a colocation datacenter operated by Switch 10 miles from the TACC campus as the preferred hosting option for the core *Horizon* system. Alternatively, a new datacenter would be constructed on the TACC campus. Risks and opportunities related to both site options are being analyzed for impact during the Construction and Operations Stages of the project. A final decision on the site location will be determined at FDR.

Environmental Health and Safety

The project includes several health and safety-related risks in its risk register. These risks include weather and health-related events that may have a system-wide impact on the LCCF construction schedule. Contingencies have been factored into the construction schedule to mitigate these risks if necessary. Furthermore, an assessment for compliance with National Environmental Policy Act regulations has been completed by NSF OGC.

Partnership Risk

The project has established partnerships with several technology vendors. Risks of withdrawal by partners due to unforeseen business reasons are included in the risk register and are carefully monitored and managed by the project. Project assessment of these partnership risks is that the probability of their occurrence is very low. However, mitigation plans have been developed.

System Integration Risk

An experienced technology integrator for the core *Horizon* system has been identified, and overall system integration risk is low. However, several other risks related to delays in datacenter access and technology roadmap change have been identified by the project that could impact the system integration timeline and schedule. Cost and schedule contingencies have been factored into the plan to mitigate these risks.

REGIONAL CLASS RESEARCH VESSELS (RCRV) $0

Appropriated and Requested MREFC Funds for the Regional Class Research Vessel Project

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023 Estimate	FY 2024 Request
Previous Authorized Total Project Cost	$121.88	$105.00	$127.09	-	-	-	-	-
American Rescue Plan	-	-	-	-	14.05	-	-	-
Preliminary Estimate of COVID-19 Impact	-	-	-	-	-	5.00	1.98	-
Hurricane Ida Construction Impacts[1]	-	-	-	-	-	25.00	-	-
Revised Total Project Cost	**$121.88**	**$105.00**	**$127.09**	**-**	**$14.05**	**$30.00**	**$1.98**	**-**

Brief Description

The Regional Class Research Vessel project is the NSF contribution to right-sizing and modernizing the U.S. Academic Research Fleet (ARF). It is expected that an ARF that includes three RCRVs will have sufficient research usage to support efficient operations while meeting regional demands. The first RCRV, R/V *Taani,* will be operated on the West Coast by Oregon State University (OSU). The second RCRV, R/V *Narragansett Dawn*, will be operated on the East Coast by the East Coast Oceanographic Consortium led by the University of Rhode Island. The third RCRV, R/V *Gilbert R. Mason,* will be operated in the Gulf of Mexico and nearby waters by the Gulf-Caribbean Oceanographic Consortium, led jointly by the University of Southern Mississippi and the Louisiana University Marine Consortium. The FY 2024 Budget does not request any funds for RCRV and provides an update on the status of the project.

Baseline History

The RCRV project is a major component in the plan for modernizing the ARF[1], an effort that began over two decades ago. In 2001, a report from the Federal Oceanographic Facilities Committee documented the need for Regional Class vessels. In response, NSF and the Naval Sea Systems Command (NAVSEA) entered into an interagency agreement in 2004 that resulted in two candidate designs for Regional Class ships. In 2007, the Federal Oceanographic Fleet Status Report endorsed the need for NSF-built Regional Class vessels to meet future science demand and in 2009, the National Academies report *Science at Sea* described the desirable characteristics of a modern Regional Class vessel. These characteristics and other science community factors were considered by a review panel when the preferred NAVSEA design was selected. In 2012, NSF issued a solicitation for the refreshed design and potential construction of three RCRVs. OSU was selected to manage the project and received the award in 2013. Input from external review panels, the University-National Oceanographic Laboratory System (UNOLS), and the *Sea Change*[2] report was received during the period 2013 to 2015 and informed the final decision to pursue construction. The *Sea Change* report recommended

[1] National Ocean Council. Federal Oceanographic Fleet Status Report, 2013. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/federal_fleet_status_report_final.pdf

[2] Sea Change: 2015-2025 Decadal Survey of Ocean Sciences https://nap.nationalacademies.org/catalog/21655/sea-change-2015-2025-decadal-survey-of-ocean-sciences

constructing only two of the three RCRVs originally planned, but Congress ultimately appropriated funding to build all three.

In 2015, the National Science Board (NSB) authorized inclusion of funds in future budget requests, at the NSF Director's discretion, to initiate construction for the RCRV project. The Final Design Review was conducted in December 2016 and the panel recommended to NSF that the project was ready to advance to the construction stage. OSU subsequently awarded a contract for construction of the first vessel to Gulf Island Shipyards (now Bollinger Houma Shipyards [BHS]; see below) based in Houma, LA with options for two more vessels. When construction is complete, NSF plans to fund RCRV operations as part of ARF, partially leveraging savings from the retirement of older, less capable vessels.

Prior to the COVID-19 pandemic, the RCRV project had been planned within an NSB-authorized Total Project Cost (TPC) of $365.0 million. In FY 2017, $121.88 million was appropriated to facilitate the construction of three vessels, followed by $105.0 million in FY 2018 and $127.09 million in FY 2019. In December 2020, the NSF Director increased the TPC to $375.0 million to account for COVID-19 impacts that reduced the efficiency of the construction effort and increased the time to completion. In FY 2021, NSF approved the use of $14.05 million in American Rescue Plan funds to address COVID-19 impacts on the RCRV project. The FY 2022 Request of $5.0 million, in conjunction with the FY 2023 Request of $1.98 million to address continuing pandemic impacts, would increase the total appropriated RCRV funds to the revised TPC of $375.0 million. In FY 2022, $25.0 million was appropriated to cover necessary expenses related to impacts of Hurricane Ida, which heavily damaged the area around the shipyard. The impact of Hurricane Ida to the RCRV project is estimated to be $23.45 million and six months of delay. In August 2022, NSB authorized an increase to raise the TPC to $400.0 million.

Project Status

OSU is managing the construction of the RCRVs and transition to operations through a cooperative agreement with NSF, which encompasses the entire project, including tests and trials. The project is divided into four distinct phases, each funded through a separate cooperative support agreement, with award of each phase contingent upon successful completion of the prior one. These phases are:

Phase I: Project Refresh - **Complete**
Phase II: Shipyard Selection - **Complete**
Phase III: Construction – **In progress**
Phase IV: Transition to Operations – **Estimated Fall 2023**

The project completed Phase II in CY 2017, during which bids for construction of RCRV were solicited from U.S. shipyards and evaluated. The project is now in Phase III, construction. Keel-laying for the R/V *Taani* was completed in November 2018; for the R/V *Narragansett Dawn*, in May 2019; and for the R/V *Gilbert R. Mason*, in March 2020.

The RCRV project includes up to one year of final outfitting, sea trials and science equipment testing/trials for each vessel, after delivery from the shipyard, to ensure readiness to conduct science operations safely and efficiently before entry into the ARF. This will mark the beginning of Phase IV Transition to Operations. R/V *Taani* is currently scheduled to be delivered in Fall 2023 and will likely begin operations in Fall 2024. The project is planning a six-month stagger between vessel deliveries,

with the R/V *Narragansett Dawn* entering the ARF in early 2025 and R/V *Gilbert R. Mason* entering in late 2025.

In April 2021, Gulf Island Shipyards, the shipyard under contract with OSU for RCRV construction, was acquired by BHS. The contract was novated under the existing terms and conditions and assigned to BHS. Construction progress was improving as a result of the additional resources available at a larger shipyard, and BHS and OSU were concurrently replanning the project's schedule to account for more efficient processes as well as COVID-19 impacts. However, on August 29, 2021, Hurricane Ida made a direct hit on the city of Houma and on the shipyard. The Category 4 hurricane was the most powerful storm on record to directly hit Louisiana and the storm caused extensive damage to the shipyard and surrounding community. Many residents were evacuated for several weeks as electricity, water, and access to medical facilities were unavailable. In addition, RCRV equipment was damaged when the hurricane's winds destroyed two storage facilities at the shipyard. However, the main fabrication building remained intact, preventing damage to the hulls of R/V *Taani* and R/V *Narragansett Dawn* that were under construction. The evaluation of Hurricane Ida impacts, completed in May 2022, identified an additional cost of $23.45 million and an additional six months of schedule delay. In FY 2022, $25.0 million was appropriated for necessary expenses related to RCRV construction impacted by Hurricane Ida.

Summary of COVID-19 Impacts

The realized impacts to the project cost, scope, and duration resulting from COVID-19 during 2020 include a delay in delivery of the first vessel, R/V *Taani*, and slightly lesser delays for the other two vessels. In October 2020, OSU estimated likely COVID-19-specific impacts through 2021 for the entire three-ship build of $14.05 million and nine months. In addition, $5.0 million was provided in FY 2022 and $1.98 million was requested in FY 2023 for NSF-held management reserve to address potential continuing, but unforeseen, pandemic impacts that cannot be covered by budget contingency, per NSF policy.

Governance Structure and Partnerships

NSF Governance Structure

The RCRV project is overseen by the Division of Ocean Sciences (OCE) as part of the Ship Acquisition and Upgrade Program. OCE provides overall interdisciplinary science-community guidance and oversight, while the administrative location of the RCRV project in the Integrative Programs Section promotes science facilities-support expertise and coordination. RCRV project oversight is managed by a dedicated Program Officer. Cross-Foundation coordination is provided by an Integrated Project Team (IPT) that includes staff from the Large Facilities Office, Division of Acquisition and Cooperative Support/Cooperative Support Branch, Division of Institution and Award Support, Office of the Director, Office of the General Counsel, Office of the Assistant Director for Geosciences, and Office of Legislative and Public Affairs.

External Governance Structure

The RCRV project is funded through a series of agreements with OSU to manage the design refresh (conceptual, preliminary, and final designs), construction, testing and trials, and eventual operation of the first RCRV for the scientific community. The Principal Investigator for the award is the project manager (PM), who reports directly to the OSU Dean of the College of Earth, Ocean, and Atmospheric Sciences. The PM interacts directly with the NSF Program Officer and manages the RCRV

administrative staff. The project scientist is a co-principal investigator for the award. The PM manages the RCRV project team including the risk manager, earned value management and schedule specialists, contracting officer, and OSU shipyard representative (SR). The SR in turn manages the naval architect and engineering contract and oversees the OSU shipyard staff and marine science technical advisors. The RCRV Science Oversight Committee (SOC), with regional representation, multidisciplinary expertise, and independent science representatives conducting research in mission areas supported by federal stakeholders (NSF, Office of Naval Research [ONR], and National Oceanic and Atmospheric Administration [NOAA]), will be active through all project phases. The SOC provides guidance to the OSU RCRV project team through the PM and/or the NSF Program Officer.

Partnerships and Other Funding Sources

NSF is the sole sponsor of RCRV construction, providing three ships for inclusion in the ARF. ARF vessels support the needs of all federal stakeholders who conduct oceanographic research, particularly NSF, NOAA, and ONR. Other users are granted access to ARF ships for research purposes, and all users pay the same daily rates. NSF is expected to support approximately 70 percent of RCRV utilization. NSF intends to make separate awards for operations to each RCRV-operating institution.

Cost and Schedule

Total Funding Requirements for RCRV

(Dollars in Millions)

	Prior Years	FY 2022 Actual[1]	FY 2023 Estimate	FY 2024 Request	ESTIMATES[2] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
R&RA:									
Development & Design	$10.47	-	-	-	-	-	-	-	-
Operations & Maintenance		-	-	1.23	10.62	15.90	16.54	17.20	17.88
Subtotal, R&RA	$10.47	-	-	$1.23	$10.62	$15.90	$16.54	$17.20	$17.88
MREFC:									
Implementation[3]	368.02	30.00	1.98	-	-	-	-	-	-
Subtotal, MREFC	$368.02	$30.00	$1.98	-	-	-	-	-	-
TOTAL REQUIREMENTS	**$378.49**	**$30.00**	**$1.98**	**$1.23**	**$10.62**	**$15.90**	**$16.54**	**$17.20**	**$17.88**

[1] The FY 2022 column includes $5.0 million from the FY 2022 NSF appropriation and $25.0 million provided under P.L. 117-43, the "Extending Government Funding and Delivering Emergency Assistance Act" for necessary expenses related to RCRV construction impacted by Hurricane Ida. The $5.0 million appropriated in FY 2022 was carried forward into FY 2023. NSF Awarded $23.45 million of the $25.00 million appropriated for Hurricane Ida in late FY 2022.

[2] Outyear estimates are for planning purposes only.

[3] Prior Years implementation includes $14.05 million of ARP funding provided to RCRV in FY 2021 that was carried forward and obligated in FY 2022.

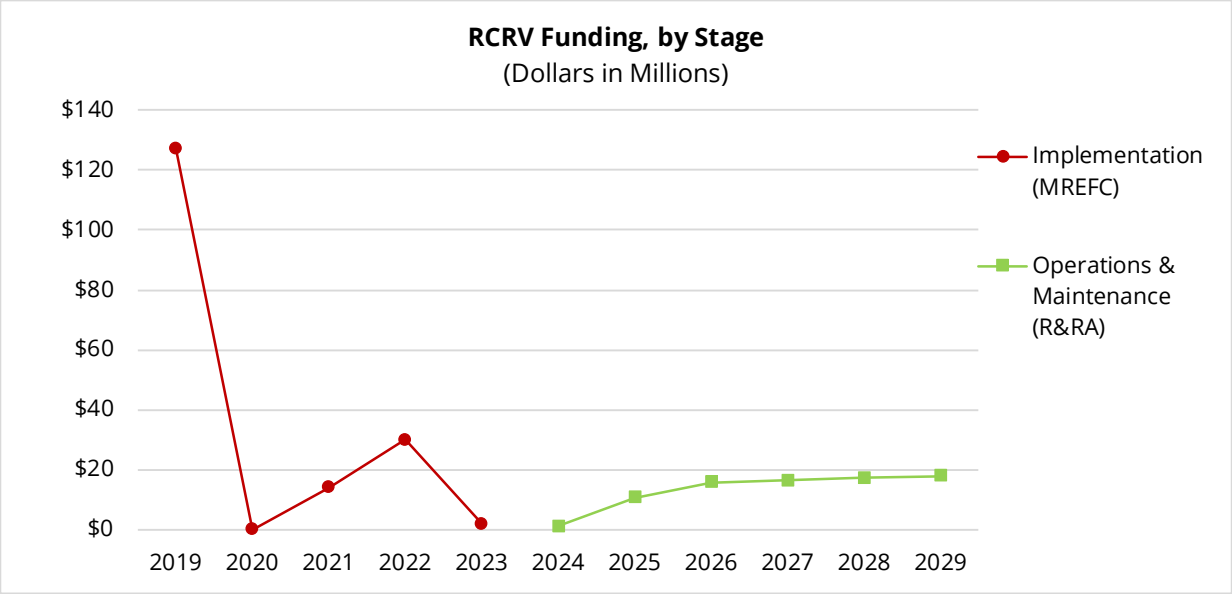
Total R&RA funding from FY 2017 to FY 2019 for RCRV design was $10.47 million. Total MREFC funding obligated to support construction is currently $391.49 million, including $14.05 million in FY 2021 American Rescue Plan/MREFC funding that was allocated to RCRV for COVID-19 impacts and $23.45 million of the $25.0 million in one-time funding appropriated in FY 2022 for necessary expenses related to RCRV construction impacts from Hurricane Ida. No additional funds were requested to address Hurricane Ida impacts in FY 2023.

Additional MREFC funding of $5.0 million was provided in FY 2022 and $1.98 million was requested in FY 2023 for NSF-held management reserve due to potential unforeseen construction delays resulting from COVID-19, that cannot be covered by budget contingency, per NSF policy. The $5.0 million

appropriated in FY 2022 was carried forward into FY 2023.

Future Operations Costs

Annual ship operations costs are well understood after several decades of experience with vessels of all classes in the ARF. OSU developed an estimate for the first year of operations assuming a robust but reasonable operating schedule of 200 days per year. OSU estimates each RCRV will cost $7.0 million to operate in its first full year, resulting in a rate of approximately $35,000 per day. This is comparable to the operating cost of current vessels after applying the appropriate multipliers for size and complexity. NSF's share of the total estimate for first full year of operations of all three ships in 2026 is $15.90 million, with other user agencies contributing the balance. The ultimate annual cost for operating three RCRVs will be partially offset by cost savings from vessel retirements elsewhere in the ARF.



Reviews

- Proposal Review: In 2012, NSF issued Solicitation 12-558, Construction of Regional Class Research Vessels, which resulted in the selection of OSU as the lead institution for construction and for operation of the first vessel.
- Design Reviews: RCRV proceeded through the standard NSF processes that included a Conceptual Design Review (December 2013), Preliminary Design Review (August 2014) and Final Design Review (FDR) (December 2016). The FDR ensured that anticipated project costs remained realistic and that no unforeseen events had arisen prior to the start of construction during FY 2017. The FDR Panel recommended that the project advance to the Construction Stage.
- Annual Progress Review: The first construction stage review was conducted in August 2018. Progress towards Design Verification and Transfer and OSU's management of the shipyard contract were evaluated. The review panel expressed confidence that the OSU Team was well qualified, had extensive relevant experience in ship acquisition, had established a positive, professional working relationship with Gulf Island Shipyards, and could deliver the three RCRVs, within budget and on schedule, that would meet science mission requirements. Quarterly

Management Reviews are conducted by OSU at the shipyard with NSF staff in attendance. The 2020 Annual Construction Review was held at Gulf Island Shipyards, while the 2021 and 2022 reviews were held virtually due to the pandemic. The review panels expressed confidence that the OSU Project Team remains capable of delivering three RCRVs to the ARF despite the current challenges (See Risks below).

Risks

The following principal risks have been identified on OSU's project risk register.

- Hull Delivery Delay: BHS replanned the construction schedule to accommodate a nine-month delay to the delivery of each hull beyond the contractual date due to the COVID-19 pandemic. An additional delay of six months was also added due to Hurricane Ida impacts. Additional delays due to known risks remain possible and are estimated to be up to 4 months.
- Transition to Operations: Experience with commissioning new research vessels demonstrates the likelihood of unplanned events that could result in the need for additional port calls during sea trials and/or construction support if equipment fails. This risk will remain until all three of the vessels are put to sea.
- Requirements Changes: All stakeholders, including the construction team, operating institutions, Science Oversight Committee, and NSF can recommend requirements changes if improvements to operations or science support justify such changes. The ability to accommodate these recommendations is related to the availability of resources and an evaluation of the necessity for them. The likelihood of realizing requirements changes is reduced as construction progresses.
- Inadequate Shipyard Performance: Shipyard's performance, including its subcontractors', will remain a risk throughout construction. Realization of this risk resulted in a pause in construction from January to August 2020, and the use of approximately $18 million in contingency, which also mitigated future likelihood of occurrence. Additionally, construction progress is improving under the new, larger shipyard owner, BHS. The February 2022 Annual Progress Review panel remarked that BHS adds resources not previously available to the project, such as fabrication of the RCRV aluminum superstructure at another BHS facility.
- Unanticipated Personnel Costs: Personnel costs or required support may be greater than anticipated for operating institutions during construction and commissioning. This risk includes higher than anticipated crew costs, including training for RCRV level of tonnage, or necessary additional personnel. This risk does not include additional time that could be required for transition to operations.

Approximately $32.20 million in budget contingency has been allocated to date as a result of realizing known risks. This amount decreased by $1.80 million from that reported in the FY 2023 Request due to the return of funds to contingency, which occurred because actual costs for completed tasks were below their estimates. A science-prioritized and time-phased scope management plan is in place to minimize impacts to science capabilities in case contingency funds are insufficient to cover realized risks. Scope reductions are not currently being considered given the expected sufficiency of remaining budget contingency. Although statistical estimates of downtime due to weather could be included in the risk model, a direct hit from a hurricane is not a risk that can be estimated probabilistically by the project team, and thus is a risk held by NSF.

VERA C. RUBIN OBSERVATORY (RUBIN OBSERVATORY) $7,610,000

Appropriated and Requested MREFC Funds for Vera C. Rubin Observatory
(Dollars in Millions)

	Prior Years	FY 2019	FY 2020	FY 2021[1]	FY 2022	FY 2023[2] Estimate	FY 2024 Request[2]	Total Project
Previous Authorized Total Project Cost	$331.72	$48.82	$46.35	$40.75	$5.36	-	-	$473.00
Current Authorized Total Project Cost (COVID-19)	-	-	10.00	-	-	-	-	10.00
Preliminary Estimate of Future COVID-19 Impact	-	-	-	-	35.39	15.00	7.61	58.00
American Rescue Plan	-	-	-	30.00	-	-	-	30.00
Estimate after Rebaseline	**$331.72**	**$48.82**	**$56.35**	**$70.75**	**$40.75**	**$15.00**	**$7.61**	**$571.00**

[1] In December 2021, based on the recent re-baseline of the Rubin construction project, NSB authorized a new Total Project Cost of $571.0 million.

[2] The FY 2023 appropriation, together with the FY 2024 Request, are based on the current best estimate of the total funding needed to address COVID-19 impacts. The COVID-19 situation continues to evolve, and ongoing schedule and cost impacts may lead to revisions of this funding plan.

Brief Description

Vera C. Rubin Observatory will comprise an 8.4-meter wide-field optical telescope located on Cerro Pachón in northern Chile, a 3.2-gigapixel camera supplied by the Department of Energy (DOE), and an advanced data management system. Taken together, these components are designed to carry out a deep survey of nearly half of the sky that will enable a broad range of fundamental astrophysical studies by the research community. Begun in August 2014, FY 2024 represents the eleventh year of support for the construction project, originally planned to last 99 months. The original NSB-authorized Total Project Cost (TPC) was $473.0 million for NSF's contribution to Rubin Observatory, which is a joint project of NSF and DOE. Delays due to the COVID-19 pandemic have now shifted the expected project completion to late 2024. The FY 2024 NSF request for Rubin Observatory is $7.61 million. This request is based on the re-baselined plan to complete construction given the approximately 27-month-delay and the revised TPC of $571.0 million[1] approved by the NSB in December 2021. The impacts of COVID-19 are described in more detail in the Project Status section.

Future operations of Rubin Observatory will be fully integrated into NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab), which launched at the start of FY 2020 (Rubin Observatory construction is a stand-alone project outside NOIRLab). NOIRLab also includes the Mid-Scale Observatories, the Community Science & Data Center, and the Gemini Observatory.

Baseline History

Rubin Observatory is a joint NSF and DOE project to build an instrument that was ranked as the top large ground-based astrophysics project recommended by the National Academies of Sciences, Engineering, and Medicine 2010 Astronomy and Astrophysics decadal survey: *New Worlds, New Horizons in Astronomy and Astrophysics*.[2]

[1] NSF intends to draw upon multiple funding sources to cover the additional costs. NSF reprogrammed $10.0 million from FY 2020 funds within the MREFC account, originally intended for the Antarctic Infrastructure Modernization for Science project which did not need all its appropriated funds in FY 2020 because of the COVID-19 pandemic. In FY 2021, NSF allocated an additional $30.0 million from the American Rescue Plan appropriation to cover pandemic-related costs; these funds were carried over and used in FY 2022. The remaining funds needed to complete the Rubin construction project are requested in the FY 2023 and FY 2024 appropriations.

[2] www.nap.edu/catalog/12951/new-worlds-new-horizons-in-astronomy-and-astrophysics

Prior to NSF's construction award, NSF, DOE, and private partners invested over $130.0 million in Rubin Observatory-related work, of which about 70 percent supported design and development. About 30 percent, from non-federal funding, supported casting and polishing of the innovative combined primary-tertiary mirror (M1M3), initial site preparation, and prototype detector creation and evaluation, all of which significantly reduced construction risk.

NSF and DOE conducted a series of reviews in 2011 and 2012, including the NSF Preliminary Design Review and a subsequent cost estimation review, to determine the project baseline. Plans were kept up to date to synchronize the DOE and NSF funding profiles as reviews continued, leading to NSF's Final Design Review (FDR) in December 2013. NSF then carried out a detailed cost analysis prior to completing its design and approval process in late FY 2014.

Project Status

NSF's construction award was issued in August 2014. The primary telescope building, mirror cell lift, and mirror coating plant construction have been completed. The M1M3 mirror and cell are completed and have been safely transported to the summit of Cerro Pachón. The secondary mirror (M2) has been successfully coated at the summit facility, and staff have moved into the completed base facility in La Serena, Chile. Following the onset of COVID-19, the project has been executing activities to minimize the impact of delays on the integrated project schedule. Installation of the telescope mount assembly (TMA) on the summit resumed in January 2021. While a resurgence of COVID-19 in Chile caused significant additional delays later in FY 2021, the telescope mount's major structure is now complete. Dome installation is nearly complete, despite the earlier delays caused by weather and realization of other known risks. Commissioning activities for the Auxiliary Telescope, which will be used for calibration purposes, are proceeding well. In 2023, DOE's completed camera will be shipped to Chile for installation and integration on the telescope. NSF- and DOE-supported activities remain tightly coordinated, both at the project level and among agency program officers.

Summary of COVID-19 Impacts

- In March 2020, the project suspended all construction activity on the summit while most work on data management was able to continue through telework. Other remote activities have prioritized tasks that will help recover schedule as on-site work resumes.
- Summit construction activity began a slow ramp-up on September 28, 2020. Fortunately, no significant damage resulted from site exposure to the elements during Chilean winter storms, while summit construction was paused. Key contractors gradually returned to the summit over several months. The dome is now substantially closed. In January 2021, work on the TMA, which is on the critical path, resumed successfully, and March 2, 2021 marked the spectacular installation of the TMA's top-end assembly.
- In FY 2020, NSF authorized $10.0 million in NSF-held management reserve for any urgently required expenses necessitated by COVID-19, such as ramping down and ramping up activity on the summit, protecting exposed equipment from the elements, mitigating potential damage to sensitive equipment during the Chilean winter, and direct expenses for new procedures and protocols required for COVID-19.
- TMA work paused again for five months while some subcontractors awaited the cancellation of Chilean COVID-19 quarantines that prevented their return to the summit. The current schedule remains tentative and is subject to potential additional delays as the global pandemic continues.
- In FY 2021, the NSB authorized $12.0 million in NSF-held management reserve to sustain the

project while the re-baseline review was conducted. The amount was based on an NSF analysis of anticipated construction costs related to COVID delays and availability of authorized management reserve.

- In December 2021, the NSB authorized a new TPC of $571.0 million, based on the re-baselined plan for the construction project, including an additional $98.0 million for realized and potential impacts caused by the COVID-19 pandemic and new data security requirements identified since project initiation. The estimated cost took into account a projected 22-month schedule delay and estimated remaining uncertainty in COVID-19-induced schedule delay (currently an additional 5 months). This action also moves the anticipated final year of MREFC funding to FY 2024.
- NSF's re-baseline process is expected to be completed in FY 2023.

Meeting Intellectual Community Needs

The site on Cerro Pachón, Chile, was selected for Rubin Observatory because of the excellent sky transparency and image quality, dark skies, small fraction of cloudy nights, and the geological characteristics that enable the rapid telescope motions required to carry out Rubin Observatory's 10-year survey. Rubin Observatory will collect about 20 terabytes of multi-color imaging data every night[3] for 10 years, producing a long-lived data set of unprecedented utility. It will produce the widest-field sky image ever and issue alerts for changing and transient objects within 60 seconds of their discovery. Repeated deep imaging of the sky accessible from Cerro Pachón will identify explosive events such as cataclysmic variable stars, supernovae, and the optical counterparts of X-ray flashes, and will find new moving objects and better characterize those already known. Estimates of Rubin Observatory's ability to locate Near Earth Objects (NEOs)[4] and Potentially Hazardous Asteroids (PHAs)[4] have been refined by the Rubin Observatory project members,[5] as well as by external studies, including an independent Jet Propulsion Laboratory study[6] supported by NASA's Planetary Defense Coordination Office. Assuming other existing NEO efforts continue, at the end of Rubin Observatory's 10-year initial survey, the catalogue for objects larger than about 140 meters across should be about 75 percent complete for NEOs (about 80 percent for PHAs). Without Rubin Observatory, the completeness would be about 60 percent for NEOs (about 65 percent for PHAs).

While the facility is under construction, there are no science users. However, the Rubin Observatory project expects to create a science-ready database of enormous utility throughout astrophysics research and education. Rubin Observatory's data will be widely accessible, and discovery opportunities will be available to K–12 students as easily as to professional astronomers. An innovative citizen science program will involve people of all ages in Rubin Observatory discoveries. About half the cost during operations is for data management, including the development of user-friendly interfaces tailored for the different anticipated communities. The survey strategy makes the same data set usable for the astrophysics community as for educators and the public.

[3] See Ivezić et al. (2019), *The Astrophysical Journal,* 873, 111.

[4] NEOs are objects that come within 1.3 astronomical units (au, the distance from Earth to Sun) of the Sun, which means they come near Earth's orbit. PHAs are defined as objects that come within 0.05 au (roughly 7.5 million kilometers) of Earth and are larger than roughly 140 meters in diameter.

[5] www.doi.org/10.1016/j.icarus.2017.11.033

[6] www.arxiv.org/abs/1705.06209

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is provided by a program officer in the MPS Division of Astronomical Sciences (AST) working cooperatively with other NSF staff through the Integrated Project Team, which has members from MPS, Office of International Science and Engineering, BFA, the Office of the General Counsel, the Office of Legislative and Public Affairs, and the Office of the Director. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. The MPS Facilities Team and NSF's Chief Officer for Research Facilities also provide high-level guidance and oversight support for the project. The NSF program officer works closely with counterparts in the DOE Office of High Energy Physics, who have oversight responsibility for the construction and commissioning of the camera.

External Governance Structure

The responsible awardee for Rubin Observatory construction is the Association of Universities for Research in Astronomy, Inc. (AURA), a non-profit science management corporation. The Rubin Observatory Project Office is an AURA-managed center for construction, and AURA established a separate management council that oversees it. The project director and project manager are experienced in large facility construction and operation and are appointed by AURA, with the approval of NSF and DOE.

AURA is also the responsible awardee for Rubin Observatory pre-operations ramp-up activity that began in October 2018 and for coordinating construction activities and pre-operations activities that are executed side-by-side. Pre-operations activities are fully integrated into NOIRLab for which AURA has a separate NOIRLab Management Oversight Council. The NOIRLab management team works with the Rubin Observatory Operations Director to oversee NOIRLab integration activities as Rubin Observatory prepares for operations.

Partnerships and Other Funding Sources

The Rubin Observatory Project is a partnership between NSF and the DOE Office of High Energy Physics, with NSF as the lead agency. Private funding totaling approximately $39 million was critical for reducing risk and beginning the fabrication of the novel primary telescope mirror prior to the initiation of the NSF and DOE construction projects. DOE is providing the world-leading 3.2-gigapixel digital camera and is contributing to design, development, installation, commissioning, operations, and scientific research support. Interagency coordination is accomplished through weekly meetings of the NSF-DOE Joint Oversight Group (JOG) and was formalized through a Memorandum of Understanding signed in July 2012. The JOG coordinates all aspects of activities during all phases of the project. The DOE-funded effort is managed by the SLAC National Accelerator Laboratory.

Cost and Schedule

NSF obligations for design and development (D&D) are complete at $57.13 million; other contributions to D&D came from DOE ($26.0 million) and from private support (approximately $13 million).

In 2013, the FDR panel considered the proposed TPC of $473.0 million to be reasonable and recommended that the project improve its planning of potential descoping options. NSF carried out further cost review prior to making the Construction Stage award. The Project Team performed a

Monte Carlo analysis on its resource-loaded integrated master schedule and determined the probability of completing the project within the proposed budget and by the planned survey start date of October 1, 2022, to be over 90 percent. As described more fully above, it is expected that the COVID-19 pandemic will impose a delay of approximately 27 months in project completion with a cost increase that is currently estimated to be approximately $98 million above the original TPC of $473.0 million. DOE's baseline cost for the camera was fixed at $168.0 million.[7] The total construction cost also included approximately $39 million from non-federal sources, all of which have been expended.

The FY 2024 NSF Request level for Rubin Observatory will enable the construction project to account for the impacts of COVID-19 and continue progress to completion in 2024. It is based on the re-baselined plan, incorporating the funding needed to address the delays due to COVID-19. The COVID-19 situation continues to evolve, and ongoing schedule and cost impacts may lead to revisions.

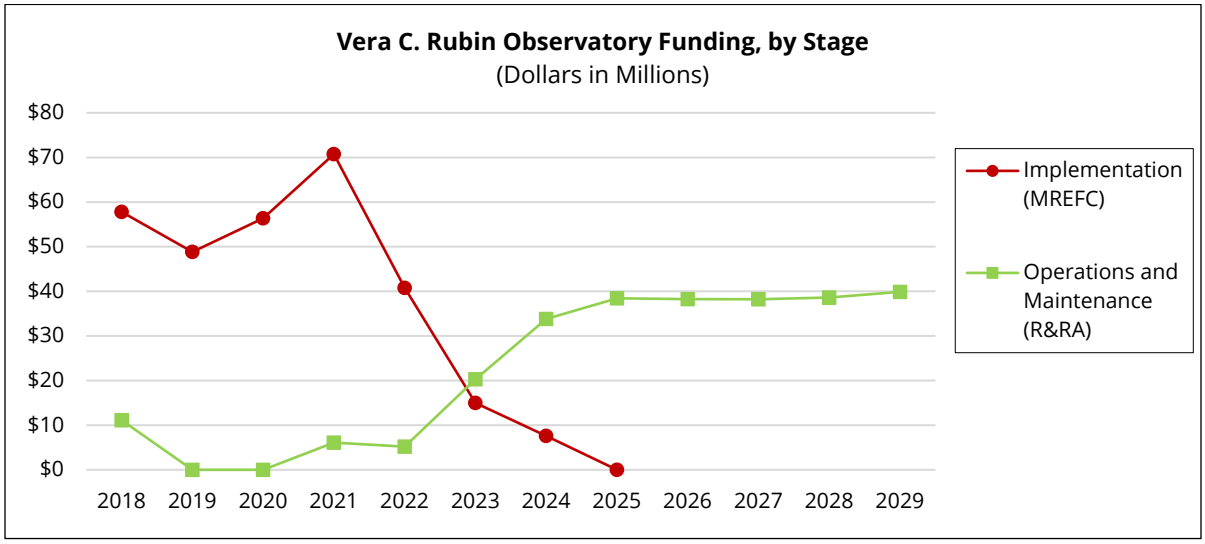
Total Funding Requirements for Vera C. Rubin Observatory

(Dollars in Millions)

	Prior Years	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
R&RA:									
Development & Design	$57.13	-	-	-	-	-	-	-	-
Operations & Maintenance		5.20	22.10	33.80	38.45	38.25	38.22	38.63	39.88
Subtotal, R&RA	$57.13	$5.20	$22.10	$33.80	$38.45	$38.25	$38.22	$38.63	$39.88
MREFC:									
Implementation[2]	507.64	40.75	15.00	7.61	-	-	-	-	-
Subtotal, MREFC	$507.64	$40.75	$15.00	$7.61	-	-	-	-	-
TOTAL REQUIREMENTS	**$564.77**	**$45.95**	**$37.10**	**$41.41**	**$38.45**	**$38.25**	**$38.22**	**$38.63**	**$39.88**

[1] Outyear funding estimates are for planning purposes only. A new cooperative support agreement for O&M is anticipated in FY 2023. These values represent NSF support only, and amount to about 50 percent of the total operations cost. DOE provides the balance of the funding required, while non-federal contributors will also provide some in-kind contributions.

[2] Prior Years implementation includes $30.0 million of ARP funding provided to Rubin in FY 2021 that was carried forward into FY 2022.



[7] Any COVID-related changes in the DOE camera costs are outside the scope of the NSF Request.

Future Operations Costs

The total annual operations cost for Rubin Observatory is currently estimated to be about $72.0 million in the first full year of operations (FY 2025), and NSF and DOE are partnering on observatory operations. The full operations cost estimates through FY 2027 were determined through a review, approval, and award process, which was completed in late FY 2022.

Initial pre-operations funding began with NSF providing $11.10 million in FY 2018 for the period FY 2019–FY 2021, with an additional $6.09 million awarded in FY 2021 to cover the COVID-19 delays through FY 2022. The balance of Rubin Observatory pre-operations and full operations funding for the period FY 2023–FY 2027 is currently being funded as part of the NOIRLab-wide operations plan.

In FY 2019, NSF and DOE jointly established a new model for in-kind contributions from international participants. The shift from cash contributions mitigates the risk of future funding for operations being inadequate, at the cost of a larger commitment from the federal agencies. Nominally, in-kind contributions are expected to benefit U.S. and Chilean scientists and/or offset NSF and DOE operations costs. The specific nature of these in-kind contributions is currently being formulated and negotiated with international participants.

Reviews

Technical Reviews

Stage-gate reviews were conducted throughout the Design Stage, culminating in NSF's FDR in December 2013, with DOE involvement. All major subsystems have undergone regular system-level reviews organized by the Rubin Observatory Project Office during Design and Construction.

Management, Cost, and Schedule Reviews

Cost, schedule, and risk are also scrutinized during the technical reviews. During construction, NSF and DOE hold regular joint progress reviews. The most recent reviews are summarized below.

- A joint agency-led review of the project re-baseline request was held June 15-17, 2021. The review looked at the Project's performance to date and the execution plan, including technical scope, cost, schedule, and the safety and risk management plans. The reviewers endorsed the re-baseline request and recommended revisions to document costs in greater detail and to update the request following a more certain restart of TMA work on the summit.
- An EVMS surveillance review of the re-baseline request coincided with the re-baseline review and focused on the impacts of the COVID-19 pandemic. The review team identified several items to improve in the re-baseline request to assure confidence in the revised TPC.
- The seventh joint agency progress review occurred in October 2021 with a positive outcome. The review was comprehensive but with particular focus on the work remaining, the readiness of the project team for the re-baselined activities, the on-going COVID-19 response, definition of construction completeness criteria, and the planned transition to operations.
- In February 2022, NSF and DOE held a joint review of the project team's latest operations plan and the five-year proposal (through FY 2027) for pre-operations ramp-up activity and the beginning of survey operations activity. A panel of expert external reviewers commended Rubin Observatory's "strong leadership team" and found the project to be "well on track to be ready for operations in FY 2024."
- The eighth joint agency progress review occurred in September 2022 with a positive outcome.

The review was again comprehensive, and it emphasized completion of the work remaining, refinement of the detailed schedule, definition of construction completeness criteria, and the transition to operations.

- A completeness review of the Education and Public Outreach (EPO) component of the construction project was conducted successfully in December 2022. A panel of experts reviewed the deliverables of the EPO component and found that the activities have been completed according to the specified criteria, and within budget and schedule.

Risks

Technical

Much of the technical risk was retired during development and design and, since full construction began, no new major technical risks have been identified. Realized risks have been mitigated by use of budget and schedule contingency or re-planning by the Rubin Observatory Project Office. The Data Management (DM) effort was previously identified as a risk and subsequently re-planned following panel recommendations from a July 2017 DM review, including the use of contingencies. Careful planning to stage DM deliverables in coordination with commissioning sequencing will mitigate the remaining risks associated with DM. Commissioning plans overall have strategies to mitigate technical risks as the entire system is assembled and integrated over the final two years.

Site

The possible site risk due to local geological anomalies was realized during excavation and successfully handled. Site disruptions from geologic events and extreme weather remain as possible risks with appropriate mitigation plans.

Environmental Health and Safety

The Rubin Observatory project has a full-time head of safety with experience in AURA operations, which has a long history of an excellent safety record in Chile. Both the summit and base sites have on-site safety supervisors employed by the Observatory to monitor contractor and project activities. All safety plans are fully compliant with applicable standards from U.S., Chilean, and participating institutions, and are updated regularly. External reviews have given the project high marks for its safety culture. In FY 2020, AURA initiated appropriate policies, procedures, and protocols to adapt to working safely in the global COVID-19 pandemic. Such policies are reviewed and adjusted as conditions in various locations evolve. Risks due to currently anticipated COVID-19 conditions are included in the project re-baseline, whereas risks due to unpredictable evolution of COVID-19 conditions are held by the federal agencies.

Partnership Risk

Significant attention has been paid to partnership risk, and that risk has been mitigated by careful coordination and unified project governance and management structures. The Rubin Observatory Project Director oversees the entire project. A single Project Manager, agreed to by both NSF and DOE, manages the complete work breakdown structure and associated work packages daily. Remaining project risks can impact the cost and schedule of each phase of the project. Such risks may affect one or both partner agencies, and the Project Manager carefully manages, coordinates, and mitigates such risks accordingly. Budgetary management details are clearly set out between the Project Director, the Project Manager, the project's Change Control Board, AURA's Management Council for Rubin Observatory construction, and the agencies' Program Officers, Grants and Agreements Officer, and

AST financial managers.

System Integration Risk

Final delivery of the integrated project will include completion of the NSF construction scope (site, telescope, and data management system) and the DOE construction scope (the 3.2-gigapixel camera). Late delivery of any subsystem could delay project completion. The project management team continually monitors the risk of late deliveries and plans mitigation strategies to reduce potential impacts on the overall project cost and schedule.

Credit: Y. AlSayyad/Rubin Obs./NSF/AURA.

MID-SCALE RESEARCH INFRASTRUCTURE TRACK 2 (MID-SCALE RI-2) **$105,060,000**

Appropriated and Requested MREFC Funds for the Mid-Scale Research Infrastructure Track 2 Program[1]

(Dollars in Millions)

FY 2022 Actual[2]	FY 2023 Estimate	FY 2024 Request	FY 2025 Estimate	FY 2026 Estimate	FY 2027 Estimate	FY 2028 Estimate	FY 2029 Estimate
$36.67	$76.25	$105.06	$85.00	$90.00	$100.00	$100.00	$100.00

[1] Outyear estimates are for planning purposes only. NSF will evaluate mid-scale in the context of agency priorities for each future budget submission.

[2] Carryover funds of $98.42 million are expected to be obligated on existing awards (about $40.0 million) and initial increments of new awards in quarters 2 and 3 of FY 2023. See the carryover statement in the Technical Information chapter for more information.

Scientific Purpose

The Mid-scale Research Infrastructure program is an NSF-wide effort to meet the research community's needs for modern research infrastructure to support priority science and engineering research. Here, we describe Track 2 (Mid-scale RI-2), covering projects with individual implementation costs between $20.0 million and $100.0 million, with funding provided from the MREFC account.

Baseline History

The scientific importance of mid-scale research infrastructure is reflected in the 2017 American Innovation and Competitiveness Act (AICA), which directed NSF to "evaluate the existing and future needs, across all disciplines supported by the Foundation, for mid-scale projects." NSF issued a Request for Information in late 2017 that resulted in nearly 200 ideas for research infrastructure with project costs in the $20.0 million to $100.0 million range, amounting to a prospective demand for approximately $10 billion in funding. The Mid-scale RI-2 track is intended to respond directly to that demand.

In the 2018 appropriation for NSF, report language from the House of Representatives encouraged the NSB "to consider further changes that would bridge the gap between the Major Research Instrumentation program and the MREFC account while also developing processes appropriate for mid-scale infrastructure, cyberinfrastructure, and instrument upgrades to be funded through the MREFC account." The NSB issued a report (NSB-2018-40)[1] that made several recommendations, including "a long-term *agency-level* commitment to mid-scale research infrastructure."

NSF response to NSB recommendations and the AICA mandate to develop a strategy was the detailed Mid-scale RI program. As part of that strategy, funding for the mid-scale projects with implementation costs above $20.0 million was requested in the MREFC account as Track 2 of an NSF-wide mid-scale program, and funding was appropriated in that account beginning in FY 2020. NSF issued its first solicitation for Mid-scale RI-2 in December 2018, requesting proposals with total implementation costs

[1] www.nsf.gov/nsb/publications/2018/NSB-2018-40-Midscale-Research-Infrastructure-Report-to-Congress-Oct2018.pdf

in the range between $20.0 million and $70.0 million. A second solicitation[2] with a new upper limit of $100.0 million was issued in December 2020 and full proposals were received in September 2021. These proposals have undergone a series of reviews, including scientific and technical panels, site visits, and reverse site visits focused on project management. The award portfolio was authorized in February 2023 and award decisions are anticipated by April 2023. The next solicitation for Mid-scale RI-2 is anticipated to be released in mid-CY 2023.

Since Mid-scale RI-2 is a portfolio of implementation awards that span all NSF research communities, it does not have a single set of *a priori* scientific goals. In the 2020 solicitation, NSF stated that "[t]he Mid-scale Research Infrastructure programs are aimed at transforming scientific and engineering research fields as well as science, technology, engineering, and mathematics education research by making available new capabilities, while simultaneously training early-career researchers in the development, design, and construction of cutting-edge infrastructure." The solicitation defines research infrastructure as "any combination of facilities, equipment, instrumentation, or computational hardware or software, and the necessary human capital in support of the same." Past examples of mid-scale-size awards in individual directorates have included items such as mid-size telescopes or telescope systems, replacement of the Palmer Pier in Antarctica, next-generation computer networking testbeds, and higher-sensitivity instrumentation at LIGO. Results from the first NSF-wide solicitation are discussed below.

Total Funding Requirements for Mid-scale RI-2[1]

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	ESTIMATES[2] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
R&RA:								
Development & Design	-	-	-	-	-	-	-	-
Subtotal, R&RA	-	-	-	-	-	-	-	-
MREFC:								
Implementation	$67.77	$76.25	$105.06	$85.00	$90.00	$100.00	$100.00	$100.00
Subtotal, MREFC	$67.77	$76.25	$105.06	$85.00	$90.00	$100.00	$100.00	$100.00
TOTAL REQUIREMENTS	**$67.77**	**$76.25**	**$105.06**	**$85.00**	**$90.00**	**$100.00**	**$100.00**	**$100.00**

[1] Operations costs to be borne by the lead disciplinary directorates are not included in this table but are discussed below in the section on Future Operations Costs.

[2] Outyear numbers are for planning purposes only. NSF will evaluate mid-scale in the context of agency priorities for each future budget submission.

Management and Oversight

Mid-scale RI-2 proposals have been received from all scientific disciplines covered by NSF, as noted above. In anticipation of the funding of such proposals, the NSF Major Facilities Guide (NSF 19-068)[3] was updated with an extensive discussion of management and oversight processes for Mid-scale RI, found in Section 5 of that Guide. That guidance has been further refined in the newest version of the

[2] www.nsf.gov/pubs/2021/nsf21537/nsf21537.pdf

[3] www.nsf.gov/pubs/2019/nsf19068/nsf19068.pdf

Guide, now called the NSF Research Infrastructure Guide (NSF 21-107).[4] Because of the varied nature of potential Mid-scale RI-2 awards, the Research Infrastructure Guide states the following:

> "Mid-scale project oversight requirements are to be tailored based on each project's unique characteristics such as the technical scope, the type and mix of work performed (e.g., standard procurement by the Recipient, software development, or civil construction), and an assessment of the associated technical and programmatic risks. However, NSF is committed to the principle that this flexibility does not preclude the requirement for appropriate rigor on the part of NSF or the Recipient. Appropriate use of NSF major facility oversight practices will be determined on a case-by-case basis…"

Each mid-scale project is overseen by a program officer from a relevant research directorate as well as a grants and agreements officer from BFA. Additionally, within BFA, the Large Facilities Office has designated a liaison for the entire mid-scale portfolio, including the Mid-scale RI-2 program, to assure a consistent and effective approach to project management oversight for these awards. To enable appropriate oversight, all Mid-scale RI-2 proposals are required to include a detailed Project Execution Plan. This plan helps NSF assess project risk and complexity to tailor the oversight for each project once awards are made.

Oversight requirements for individual awards are detailed in the grant or cooperative agreement terms and conditions. Portfolio-wide oversight, ensuring that the Mid-scale RI-2 program meets its overall objectives, is led by the Deputy Chief Officer for Research Facilities in the Office of the Director.

Mid-scale RI Track 2 Status

NSB authorization for the first Mid-scale RI-2 awards was given in May 2020. The authorized awards underwent full cost analyses and final award negotiations, including Independent Cost Estimates (as appropriate) required under AICA and assessment of any imminent impacts from COVID-19. The first three Mid-scale RI-2 awards, made from the MREFC account in October 2020, are listed below and described further in an NSF special report[5]:

- "High Magnetic Field Beamline," Cornell University, $32.69 million
- "Global Ocean Biogeochemistry Array," Monterey Bay Aquarium Research Institute, $52.94 million
- "Grid-Connected Testing Infrastructure for Networked Control of Distributed Energy Resources," University of California at San Diego, $39.47 million.

NSB authorized additional awards for proposals from the first solicitation in February 2021. The fourth award was made in June 2021, and a fifth award was announced in February 2022:

- "Network for Advanced NMR [Nuclear Magnetic Resonance]," University of Connecticut, $39.70 million.[6]
- "Research Data Ecosystem: A National Resource for Reproducible, Robust, and Transparent Social Science Research in the 21st Century," University of Michigan, $38.36 million.[7]

[4] www.nsf.gov/pubs/2021/nsf21107/nsf21107.pdf
[5] www.nsf.gov/news/special_reports/announcements/102920.jsp
[6] www.nsf.gov/news/special_reports/announcements/061621.jsp
[7] www.nsf.gov/news/special_reports/announcements/020422.jsp

As stated above, a solicitation for a second round of proposals for Mid-scale RI-2 was released in December 2020. NSF anticipates making new awards from that competition in the first half of FY 2023.

Future Operations Costs

The Mid-scale RI-2 solicitations specifically prohibited inclusion of operations costs in the individual project budgets, but proposers were required to present operations and utilization plans as well as estimates of full lifecycle costs. For each individual proposal considered for inclusion in the award portfolio, the lead directorate was required to estimate and commit to any additional operations costs necessary to reap the scientific benefits of an award. At a hypothetical level of $200 million in awards from the first solicitation and an estimated upper limit to the operations cost of 10 percent of the capital costs per project per year,[8] the total operations cost impact from the first round of Mid-scale RI-2 awards could potentially ramp up to a steady state of no more than $20 million per year by FY 2025. Given the variety of operational models for the funded infrastructure, this cost would only be partially borne by NSF.[9] Operations costs of projects funded from the second solicitation, released in FY 2021, and from subsequent solicitations, would not begin until well after FY 2025.

Reviews

The Mid-scale RI-2 proposals do not go through the Conceptual/Preliminary/Final Design phases and accompanying reviews typical of major facility projects, which enables a more agile process for these important, but smaller, projects. However, the Mid-scale RI-2 program only considers projects that have reached a high state of readiness for implementation through previous investments in development. The program has been designed to include a two-step, pre-proposal/full-proposal process to limit the burden on the research community of both preparing and reviewing full proposals. Lead NSF directorates are identified to review each pre-proposal and full proposal. Pre-proposals are externally reviewed according to the standard NSF merit review criteria and solicitation-specific review criteria, with a subset invited to submit full proposals. Those full proposals are also externally reviewed, with a subset selected for a Site Visit. Based on the results of the site visit, a further subset of proposals is invited to a Reverse Site Visit at NSF (or held virtually) for detailed assessment of the Project Execution Plans. Some highly meritorious projects with weaknesses in their Project Execution Plans may be asked to submit revised Project Execution Plans, responding to reviewer recommendations and subsequent NSF guidance, before final funding recommendations are made.

Based on the extensive input from external merit review, the most meritorious proposals are identified by the lead directorates and submitted to the Mid-scale RI-2 Working Group. That working group prepares sample portfolios of those proposals at different levels of total funding and forwards them to the Office of the Director for further consideration. The Deputy Chief Officer for Research Facilities convenes an independent Portfolio Recommendation Group to evaluate the portfolios from the working group and develop one or more final recommended portfolios that take into account strategic agency considerations, technical and programmatic risk, projected funding availability, and

[8] www.nsf.gov/nsb/publications/2018/NSB-2018-17-Operations-and-Maintenance-Report-to-Congress.pdf

[9] An annual operations cost of 10 percent of the total capital costs is a typical “high-end” estimate for a major infrastructure project. Since some of the Mid-scale RI-2 awards being made by NSF are additions to existing facilities or infrastructure, the predicted increments to the operations costs are less than that high-end estimate for several projects.

overall portfolio balance. During the portfolio construction process, NSF also conducts a rigorous cost analysis of each candidate project to ensure compliance with the Government Accountability Office good practices as required by the solicitation and with the Research Infrastructure Guide. That analysis may inform modifications to the award portfolio if it reveals substantial deficiencies in the proposed cost of a project. Once finalized, the Director recommends, and the NSB authorizes, the full portfolio of awards.

Risks

Technical risks and risk management for the individual projects are included as part of the Project Execution Plans and evaluated rigorously by an external panel of project management experts. The construction of the final portfolio also relies significantly on an evaluation of agency risks. These include, for example, a constraint that not all the projects should have very high or very low technical risk,[10] potential cost risks identified during the review process, assessment of any partnership risks, the risk that events out of the control of an awardee might significantly impact an individual project, and/or the risk of overcommitting future budgets such that the next solicitation might be significantly delayed.

[10] NSF does not want all projects to have very high technical risk, because of the desire for a high probability of very successful projects coming out of the Mid-scale program. On the other hand, NSF does not want all projects to be "safe" projects with very low technical risk, because a portfolio consisting only of such projects might have less potential for dramatic increases in scientific knowledge.

MAJOR FACILITIES OVERVIEW

Major Facilities Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Change over FY 2023 Base Total[1] Percent
Total Research and Related Activities	**$996.89**	**$970.94**	**$44.23**	**$2.50**	**$1,017.67**	**$1,084.91**	**$69.74**	**6.9%**
Operations and Maintenance of Existing Facilities	680.14	663.49	18.43	-	681.92	717.61	35.69	5.2%
Federally Funded Research and Development Centers	300.61	285.02	13.70	2.50	301.22	318.39	19.67	6.6%
Operations and Maintenance of Facilities under Construction	5.20	10.00	12.10	-	22.10	33.80	11.70	52.9%
R&RA Design Stage Activities	10.94	12.43	-	-	12.43	15.11	2.68	21.6%
Major Research Equipment and Facilities Construction	**$119.95**	**$186.23**	**-**	**-**	**$186.23**	**$303.67**	**$117.44**	**63.1%**
Total, Major Multi-User Research Facilities	**$1,116.84**	**$1,157.17**	**$44.23**	**$2.50**	**$1,203.90**	**$1,388.58**	**$187.18**	**15.6%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

NSF investments in major multi-user research facilities (major facilities) provide large, state-of-the-art tools for research and education. These can include instrumentation networks, observatories, accelerators, telescopes, research vessels, aircraft, and simulators. In addition, scientific use of cyber-enabled and geographically distributed facilities continues to increase as a result of rapid advances in computer, information, and communication technologies. NSF's investments are coordinated with those of other organizations, federal agencies, and international partners to ensure they are complementary and well-integrated. Planning, operations, and maintenance of major facilities are funded through the R&RA account. Most construction is funded through the MREFC account.

In FY 2018, NSF created the position of Chief Officer for Research Facilities in the Office of the Director, to enhance oversight of major facilities throughout their complete lifecycle. The individual in that position serves as the senior agency official whose responsibility is oversight of the development, construction, and operations of major facilities across the Foundation, as required by Section 110 of the American Innovation and Competitiveness Act (P.L. 114-329). In FY 2022, a Deputy Chief Officer for Research Facilities position was created to provide oversight for NSF's Mid-scale Research Infrastructure portfolio.

The Program Management Improvement and Accountability Act requires an annual NSF portfolio review integrated with an agency Strategic Review. In FY 2019, the NSF Strategic Review evaluated practices in funding NSF's Major Facilities and lessons learned from the FY 2019 lapse in appropriations. As a result, NSF established a requirement to have at least three months of funding obligated to the major facility awards to span potential periods of funding discontinuity, thus providing financial stability. The FY 2020 Strategic Review assessed options for improving NSF internal processes for the Development and Design Stages. The Office of the Director and the Large Facilities Office have implemented recommendations from this review, including collecting consistent information annually from all Divisions on projects in development to promote strategic awareness, building capacity in project management expertise for NSF staff and the research community through training opportunities and engagement, and clarifying the process for projects to enter the Design Stage at points beyond the Conceptual Design Phase. In FY 2022, the Strategic Review considered NSF's processes for the final lifecycle stage of facilities, termed Disposition. The Office of the Director and the Large Facilities Office are implementing recommendations from this review, including refining and consistently applying language related to disposition, developing processes for estimating the likely cost of the final lifecycle stage and clarifying expectations for how disposition will be funded and managed.

The Facility Operation Transition activity proposed in IA is the fifth year of a pilot program that reflects NSF's strategic commitment to successful O&M of new major facilities as well as balancing portfolio funding between facilities and individual investigator research, both of which were emphasized in the NSB's Congressionally requested 2018 report entitled "Study of Operations and Maintenance Costs for NSF Facilities" (NSB-2018-17).[1] The funds in this activity will be used to (1) partially support initial O&M of new facilities so that the full O&M costs can be gradually absorbed into the managing division or directorate, and (2) partially support divestment of lower-priority facilities, the full cost of which may significantly impact individual division or directorate funding. In FY 2022, these funds supported facilities operations and maintenance costs in BIO ($5.0 million) and MPS ($5.0 million); in FY 2023, the allocation of these funds to specific organizations is pending approval of NSF's FY 2023 Current Plan.

This chapter provides descriptions of each major facility supported through the R&RA account and provides funding information by lifecycle phase for each facility. The information presented for each facility follows the overall framework established by NSF for major facility projects. Information on projects under construction that are funded through NSF's MREFC account is provided in the MREFC narratives. The following pages contain information on the budget requests for NSF's major facilities in FY 2024.

[1] National Science Board, *Study of Operations and Maintenance Costs for NSF Facilities* (NSB-2018-17), May 2018, www.nsf.gov/pubs/2018/nsb201817/nsb201817.pdf.*FY 2021 Budget Request to Congress.*

MAJOR FACILITIES FUNDING, BY PROJECT

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Change over FY 2023 Base Total[1] Percent
Operations and Maintenance of Major Facilities	**$985.95**	**$958.51**	**$44.23**	**$2.50**	**$1,005.24**	**$1,069.80**	**$67.06**	**6.7%**
National Ecological Observatory Network (NEON)	69.01	71.71	-	-	71.71	78.04	6.33	8.8%
Biological Sciences	***$69.01***	***$71.71***	***-***	***-***	***$71.71***	***$78.04***	***$6.33***	***8.8%***
Academic Research Fleet	116.39	116.68	10.43	-	127.11	129.23	2.12	1.7%
Geodetic Facility for the Advancement of GEoscience (GAGE)	13.94	14.05	0.50	-	14.55	15.18	0.63	4.3%
International Ocean Discovery Program (IODP)	51.70	50.40	-	-	50.40	52.77	2.37	4.7%
National Center for Atmospheric Research (NCAR) FFRDC	104.64	110.31	5.89	-	116.20	134.41	18.21	15.7%
Ocean Observatories Initiative (OOI)	45.13	45.00	6.00	-	51.00	53.36	2.36	4.6%
Seismological Facility for the Advancement of GEeoscience (SAGE)	21.87	21.87	1.50		23.37	24.40	1.03	4.4%
Geosciences	***$353.67***	***$358.31***	***$24.32***	***-***	***$382.63***	***$409.35***	***$26.72***	***7.0%***
Arecibo Observatory[2]	12.19	6.00	-	-	6.00	6.00	-	-
Green Bank Observatory (GBO) FFRDC[3]	15.53	9.12	1.71	-	10.83	9.55	-1.28	-11.8%
Large Hadron Collider (LHC) - ATLAS and CMS	21.51	20.50	-	-	20.50	20.50	-	-
Laser Interferometer Gravitational Wave Observatory (LIGO)	45.00	45.00	-	-	45.00	50.00	5.00	11.1%
National High Magnetic Field Laboratory (NHMFL)[3]	38.91	39.91	-	-	39.91	38.57	-1.34	-3.4%
National Radio Astronomy Observatory (NRAO) FFRDC[3,4]	102.72	91.16	2.50	-	93.66	98.35	4.69	5.0%
NRAO O&M[5]	*52.09*	*40.53*	*2.50*	*-*	*43.03*	*43.59*	*0.56*	*1.3%*
Atacama Large Millimeter Array (ALMA) O&M	*50.63*	*50.63*	*-*	*-*	*50.63*	*54.76*	*4.13*	*8.2%*
National Solar Observatory (NSO) FFRDC[3]	26.54	25.46	1.10	-	26.56	27.67	1.11	4.2%
NSO O&M	*6.96*	*5.88*	*-*	*-*	*5.88*	*6.24*	*0.36*	*6.1%*
Daniel K. Inouye Solar Telescope (DKIST) O&M	*19.58*	*19.58*	*1.10*	*-*	*20.68*	*21.43*	*0.75*	*3.6%*
NSF's Nat'l Optical-Infrared Astronomy Res. Lab. (NOIRLab) FFRDC[3]	56.38	58.97	14.60	2.50	76.07	82.21	8.64	11.7%
NOIRLab O&M (Mid-Scale Obs. & Community Science & Data Ctr)[6]	*25.80*	*25.99*	*2.50*	*2.00*	*30.49*	*23.68*	-4.81	-16.9%
GEMINI Observatory O&M	*25.38*	*22.98*	*-*	*0.50*	*23.48*	*24.73*	1.75	7.6%
Vera C. Rubin Observatory O&M	*5.20*	*10.00*	*12.10*	*-*	*22.10*	*33.80*	11.70	52.9%
Mathematical and Physical Sciences	***$318.78***	***$296.12***	***$19.91***	***$2.50***	***$318.53***	***$332.85***	***$16.82***	***5.3%***
Antarctic Facilities and Operations (AFO)	237.23	224.71	-	-	224.71	241.55	16.84	7.5%
IceCube Neutrino Observatory (ICNO)	7.26	7.66	-	-	7.66	8.01	0.35	4.6%
Office of Polar Programs	***$244.49***	***$232.37***	***-***	***-***	***$232.37***	***$249.56***	***$17.19***	***7.4%***
Major Research Facilities Construction Investments	**$130.89**	**$198.66**	**-**	**-**	**$198.66**	**$318.78**	**$120.12**	**60.5%**
R&RA Design Stage Activities[7]	**$10.94**	**$12.43**	**-**	**-**	**$12.43**	**$15.11**	**$2.68**	**21.6%**
Major Research Equipment and Facilities Construction (MREFC)	**$119.95**	**$186.23**	**-**	**-**	**$186.23**	**$303.67**	**$117.44**	**63.1%**
Total	**$1,116.84**	**$1,157.17**	**$44.23**	**$2.50**	**$1,203.90**	**$1,388.58**	**$187.18**	**15.6%**

FFRDC is an acronym for Federally-Funded Research and Development Center.

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[2] Arecibo: In FY 2024, NSF will transition from a cooperative agreement for operations of Arecibo Observatory to a contract for maintenance of the site.

[3] Funding for FY 2023 and FY 2024 does not include potential additional funding that may be provided by MPS' Office of Strategic Initiatives (formerly Office of Multidisciplinary Activities) for deferred maintenance projects.

[4] NRAO: Incuded within NRAO's total funding is NSF's contribution to VLBA at $3.43 million per year.

[5] NRAO: Includes funding for the ngVLA program office.

[6] NOIRLab: Includes support for the Windows on the Universe Center for Astronomy Outreach, ongoing activities at the WIYN telescope, and potential future participation in the U.S. Extremely Large Telescope program.

[7] Includes development and design costs for the Leadership-Class Computing Facility (LCCF) of $3.50 million in FY 2022 and $7.44 million, $12.43 million, and $15.11 million for the Antarctic Research Vessel (ARV) in FY 2022, FY 2023, and FY 2024, respectively.

U.S ACADEMIC RESEARCH FLEET (ARF)

Academic Research Fleet Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$116.39	$127.11	$129.23	$2.12	1.7%

Brief Description

The U.S. Academic Research Fleet currently consists of 17 oceanographic vessels and various submersibles/autonomous vehicles owned by the National Science Foundation, the Office of Naval Research (ONR), and U.S. universities and laboratories. All ARF ships and vehicles are operated by research universities and laboratories. The ARF is a subset of the U.S. Federal Oceanographic Fleet, with collaboration under the Federal Interagency Working Group on Facilities and Infrastructure. Access to the ARF vessels and vehicles is accomplished through collaboration with the University-National Oceanographic Laboratory System (UNOLS) organization. Universities and laboratories that operate ARF vessels are designated as UNOLS operators, and as such, adhere to the UNOLS Research Vessel Safety Standards, as well as other applicable U.S. Coast Guard Code of Federal and International Maritime regulations. All ARF ships are U.S.-flagged vessels with vessels over 300 tons operating under a Certificate of Inspection and tracked by the U.S. Department of Transportation Maritime Administration.

Meeting Scientific Community Needs

The ARF consists of technologically advanced ships and submersibles/autonomous vehicles that enable scientists to conduct research in complex ocean, seafloor, and sub-seafloor environments, the Great Lakes, and remote polar regions. ARF vessels collect observational data on Earth systems that provide a foundation for understanding how these systems interact and for improved predictive modeling. Through at-sea sampling and observing, researchers have begun to understand, model, and predict responses of marine populations and systems to long-term and episodic changes in ocean conditions. Through engagement with various UNOLS committees, scientific input into the operations of ARF vessels is provided to Federal agencies to better support research community requirements.

Status of the Facility

In FY 2022, ARF vessels carried out 3,640 operating days, of which NSF-supported research accounted for a record high 78 percent. NSF and Oregon State University completed the disposition process for R/V *Oceanus* in FY 2022, making way for R/V *Taani* to be delivered in FY 2023. The *R/V Taani* is the first of the three regional class research vessels being constructed with funding from the Major Research Equipment and Facilities Construction account. Currently, ARF is experiencing a major challenge with crew retention and recruitment as global demand for ship crew is high and skilled crewmembers have competitive opportunities outside the academic fleet. NSF and ONR have funded a new position in the UNOLS office to focus on the development of initiatives to address this issue.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight of the ARF is provided by a Program Director in the Division of Ocean Sciences who works cooperatively with staff from other Divisions; the Office of Budget, Finance and Award Management (BFA); the Office of the General Counsel; and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. The GEO Senior Advisor for Facilities and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

NSF is the cognizant federal agency that supports the ARF through awards to each ship-operating institution and that provides oversight through site visits, ship inspections, Business Systems Reviews (BSRs) and participation at UNOLS council and committee meetings.

External Governance Structure

ARF operations are coordinated with stakeholders through UNOLS council and committees. The UNOLS Ship Scheduling Committee is the group that develops the annual operating schedule and maximizes efficient support for funded science. Through the UNOLS Fleet Improvement Committee, stakeholders update documents identifying capabilities needed by each ship class to support science missions, which in turn inform funding needs. The material condition of ARF vessels is determined through the NSF Ship Inspection Program, which helps determine future Fleet modernization needs.

Partnerships and Other Funding Sources

The ARF is supported through interagency partnerships, principally with ONR and the National Oceanic and Atmospheric Administration. The Fleet's operating costs are divided proportionally among vessel users based on usage. NSF supports approximately 70 percent of the total usage.

Funding

Total Obligations for ARF

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$116.39	$127.11	$129.23	$142.23	$150.38	$156.40	$162.65	$169.16

[1] Outyear estimates are for planning purposes only. Includes funding for Regional Class Research Vessels as they become operational.

Funding for the ARF includes investments in ship operations; shipboard scientific support equipment; oceanographic instrumentation and technical services; and submersible support. Increased support in FY 2023 and into FY 2024 reflects lingering impacts on ship demand and scheduling of work deferred due to the COVID-19 pandemic, as well as increased operations, higher maritime wages, and higher fuel costs. Additionally, the impact of supply chain back-logs has impacted shipyard costs.

Reviews and Reports

Each NSF cooperative agreement award with a ship-operating institution is reviewed by an external panel every five years. The current cycle of cooperative agreements ends in FY 2024. NSF has scheduled two BSRs for FY 2023: Louisiana Universities Marine Consortium (LUMCON) and the

University of Hawaii.

Renewal/Recompetition/Disposition

NSF owns two vessels in the ARF but relies on all ships to support NSF-funded research. All operating institutions received new five-year awards in 2018, which were extended to six years as NSF updates the solicitation to ensure compliance with recent legislation. NSF funded year five of the six-year awards for all the ships in FY 2022. For the ships not owned by NSF, the operating awards will be renewed in FY 2024.

After completing an internal NSF review process, a decision was made to request a 5-year renewal proposal from the University of Alaska Fairbanks for continued operations of the NSF-owned ship, R/V *Sikuliaq*. The proposal will undergo external panel review for a possible award in FY 2024. The remaining NSF-owned ship, R/V *Endeavor* is anticipated to be divested in FY 2023 and replaced by R/V *Narragansett Dawn* in early FY 2025. The third new RCRV, R/V *Gilbert R. Mason,* will replace R/V *Pelican* (owned by LUMCON) in late FY 2025 after retirement of R/V *Pelican* in FY 2024. Operators for RCRVs were chosen through a competitive process.

As noted previously, NSF and Oregon State University completed the disposition process for R/V *Oceanus* in FY 2022, making way for R/V *Taani* to be delivered in FY 2023.

ANTARCTIC FACILITIES AND OPERATIONS (AFO)

www.usap.gov

Antarctic Facilities and Operations Funding[1]

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$244.67	$237.14	$256.66	$19.52	8.2%

[1] Includes development and design costs for the Antarctic Research Vessel of $7.44 million, $12.43 million, and $15.11 million in FY 2022, FY 2023, and FY 2024, respectively.

Brief Description

Antarctic Facilities and Operations supports the infrastructure, logistics, and science operations underlying the United States Antarctic Program (USAP). In direct support of the Nation's goals under the Antarctic Treaty System, the program strives to maintain an active and influential presence in the region through fostering the conduct of world-class science and mutually beneficial international cooperation when and where appropriate. At the same time, the program strives to optimize funding efficiency while ensuring safe, environmentally sound and effective operations.

Meeting Scientific Community Needs

The research community participates actively in decisions regarding scientific platform and logistics requirements through the annual science planning process managed jointly by the Antarctic Infrastructure and Logistics (AIL) and the Antarctic Sciences (ANT) sections of OPP.

The Antarctic Infrastructure Recapitalization (AIR) program was initiated in FY 2022 in response to a 2012 Blue Ribbon Panel (BRP) report[1], which recommended that NSF create a capital plan to renew the USAP's aging physical plant. Unfunded parts of the Antarctic Infrastructure Modernization for Science (AIMS) project, currently in the construction phase, will be considered as part of the ongoing refresh of the McMurdo Station master plan and may be accomplished as part of the broader AIR program. The longer-term recapitalization of McMurdo Station and other Antarctic infrastructure under the AIR program is expected to produce further efficiencies.

Status of the Facility

The U.S. presence in Antarctica is maintained in accordance with U.S. policy and supports Antarctic Treaty administration under Department of State leadership. AFO comprises the infrastructure and logistics needed to conduct U.S. research in Antarctica, including research funded by other U.S. agencies. Activities occur on two research ships, at a variety of remote field camps, and year-round at the U.S. stations–McMurdo, South Pole, and Palmer. All support for these activities is provided through AFO, including transportation, facilities, communications, utilities (water and power), health and safety infrastructure, and environmental stewardship.

[1] www.nsf.gov/geo/opp/usap_special_review/usap_brp/rpt/index.jsp

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is provided by a program officer in GEO's Office of Polar Programs, who works cooperatively with staff from Office of Budget, Finance, and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. The GEO facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

NSF's Division of Acquisition and Cooperative Support and the Department of Interior's Interior Business Center provide contract oversight and management.

External Governance Structure

The USAP is subject to the Antarctic Conservation Act and provisions within the Antarctic Treaty, under Department of State leadership. USAP stations in Antarctica can be inspected by Treaty member nations on short term notification. The USAP has *ad hoc* reviews at 10 to 15-year intervals, with the most recent review summarized in the 2012 BRP Report. The AIR program is a significant step towards addressing the report recommendations and is covered in detail in the MREFC chapter.

Partnerships and Other Funding Sources

NSF has arrangements for cooperative sharing of logistics and science capabilities with international treaty partners operating near USAP stations and remote field sites. These arrangements mostly use in-kind contributions rather than monetary contributions. NSF performs reimbursable field work for other agencies.

In FY 2022, NSF, in partnership with NOAA, completed the Ross Island weather and communications satellite downlink/transmission station to replace aging facilities on Black Island.

Funding

Total Obligations for AFO

(Dollars in Millions)

				ESTIMATES[1]				
	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations and Maitenance[2]	$244.67	$237.14	$256.66	$269.61	$269.61	$269.61	$269.61	$269.61

[1] Outyear estimates are for planning purposes only. The main support contract ends March 2025.

[2] Includes development and design costs for the Antarctic Research Vessel of $7.44 million, $12.43 million, and $15.11 million in FY 2022, FY 2023, and FY 2024, respectively.

In FY 2024, AFO funding is increased to cover higher deployment costs and accommodate continued operation of the stations, as well as support for priority science activities including the International Thwaites Glacier Collaboration. COVID-19, and the resulting need for pre-deployment quarantine in New Zealand, has led to significantly higher per-person costs for grantees and contract personnel deploying to Antarctica. Higher deployment costs could persist into the FY 2024 season, increasing the overall operating cost even if the deployment tempo is lower than prior to the COVID-19 pandemic. Once pre-deployment quarantine periods are no longer required, the lower per-person cost will be offset by a higher deployment tempo, which will be needed to clear the backlog of field

science projects that were deferred during the pandemic.

Reviews and Reports

OPP evaluates the performance of the Antarctic support contractor annually via an Award Fee Plan, which involves multiple tiers of review, including a Performance Evaluation Board comprising NSF staff in OPP and BFA. The USAP BRP released a report on its review of the program in July 2012. The initial NSF response to the USAP BRP report was released in March 2013 and progress to address recommendations is ongoing. The AIR program is a significant step towards addressing the report recommendations and is covered in detail in the MREFC chapter.

Renewal/Recompetition/Disposition

Lockheed Martin Corporation (LMC) was awarded a 13.5-year Antarctic support contract (ASC) in December 2011. In FY 2017, LMC novated and successfully transferred management of the ASC to Leidos Corporation. The final option with Leidos was exercised in September 2022.

In anticipation of recompeting the ASC prime contract, NSF conducted a Virtual Industry Day for Operations and Science Support to the United States Antarctic Program on February 16, 2021, and issued a request for information in December 2021.

A contract for helicopter support was awarded to Air Center Helicopters in April 2019. In FY 2024 it will be in the final of four option years.

A contract for fixed-wing small aircraft support was awarded to Kenn Borek Air in August 2018. A follow-on support contract is expected to be awarded in late FY 2023.

Currently there are no plans to dispose of this facility.

ARECIBO OBSERVATORY (AO)

Arecibo Funding
(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Change over FY 2023 Estimate Base Percent
$12.19	$6.00	$6.00	-	-

Brief Description

AO is a center for multidisciplinary research and education located near the town of Arecibo in western Puerto Rico on approximately 140 acres of NSF-owned land. Through FY 2023, AO is operated and managed by the University of Central Florida (UCF) and subrecipients, Yang Enterprises, Inc. (YEI) and Universidad Ana G. Méndez (UAGM), formerly Universidad Metropolitana, under a cooperative agreement with NSF that began on April 1, 2018. On December 1, 2020, AO's 305-meter telescope suffered an uncontrolled collapse of its suspended receiver platform after failure of several supporting cables. Emergency cleanup activities were completed in Spring 2022. At the end of the current award (FY 2023), NSF will fund site maintenance and support through a direct contract that will provide a foundation to sustain a variety of activities on the Arecibo site, including the potential Arecibo Center for STEM Education and Research (ACSER) and other potential awards for scientific and educational initiatives.

Meeting Scientific Community Needs

NSF remains focused on exploring how the AO site can catalyze and inspire STEM talent and innovation in Puerto Rico for decades to come. After extensive consideration, NSF has decided to engage a contractor to maintain the site on behalf of the Foundation to allow for maximum flexibility and enable the possibility of multiple users (or "tenants") on the site. NSF is proposing to prioritize investment in educational activities and research. These educational opportunities are identified in multiple community reports as well as in the CHIPS and Science Act of 2022 (P.L. 117-167), which highlights the need to "explore opportunities for strengthening and expanding the role of the Arecibo Observatory in Puerto Rico through education, outreach and diversity programs, and future research capabilities and technology at the site."

In October 2022 NSF released the ACSER solicitation that calls for proposals to establish a STEM education and research center to capitalize on the robust educational foundation established at the AO site. The solicitation calls for projects that create and implement inclusive and innovative education research, as well as workforce development initiatives across a broad range of STEM disciplines for students, teachers, researchers, local communities, and the public within and outside of Puerto Rico. The proposed ACSER would play a significant role in modeling and advancing equitable and inclusive STEM education and research, especially in Puerto Rico and for those individuals and communities underrepresented in STEM. While the proposed ACSER would not require an active physical science research program, such a research program could be incorporated in responses to the ACSER solicitation or in future proposals.

Status of the Facility

AO is currently operated under a cooperative agreement with UCF that was scheduled to end on March 31, 2023. After a careful review of the different options, NSF decided not to renew the cooperative agreement given that the terms of the award were based on operations of the 305-meter telescope, which is no longer functional. However, NSF extended the cooperative agreement to May 31, 2023 and plans to further extend it through September 30, 2023 to provide ample time to close out the current award and ensure a successful transition to the next phase of activity at the Arecibo site. NSF's engagement of a site contractor will ensure the continuity of site maintenance independent of the site use while other short-term opportunities are pursued and longer-term options are explored. NSF is working with the Small Business Administration to identify an appropriate contractor, preferably based in Puerto Rico, to take on the site maintenance role.

Beyond the potential ACSER initiative, NSF's new site maintenance contract provides a flexible foundation that can also support other potential awards for current and future uses of the site, allowing implementation of innovative ideas involving the existing infrastructure or new initiatives yet to be imagined. Future use of the infrastructure and research resources on the site can be proposed and will be evaluated through NSF's standard merit review processes.

NSF is collaborating with NASA on a study of next-generation radar needs, including concepts that could involve the future use of the AO site. The study will entail a comprehensive evaluation of the needs of NASA's planetary science division, including support for planetary defense activities, and the needs of the NSF research community for future planetary science studies that could benefit from radar technology. NSF anticipates this study to be completed by the end of FY 2023.

Governance Structure and Partnerships

NSF Governance Structure

As NSF transitions from the cooperative agreement to a site contract, oversight of the Arecibo site has shifted to a coordination group with representation from the EDU, GEO, and MPS directorates. This oversight group includes a Contracting Officer (CO) and Contracting Officer Representative (COR), together with a representative from the Large Facilities Office, who provides advice and assists with agency oversight and assurance. The group also receives support from staff in the Office of the General Counsel and the Office of Legislative and Public Affairs. The Chief Officer for Research Facilities also provides high-level guidance, support, and oversight. If awarded, EDU will provide award monitoring and evaluation of the proposed ACSER initiative.

External Governance Structure

In FY 2024, the Arecibo site will be maintained for NSF by a site contractor. The CO and COR will be the primary interfaces to the contractor on behalf of NSF. NSF will work with the contractor to establish organizational structures that ensure appropriate coordination of all ongoing activities on the site.

Partnerships and Other Funding Sources

NSF's use of a site contractor provides a flexible foundation for partnership activities at the Arecibo site. NSF will continue to explore partnerships to ensure maximal practical use of the site, especially in ways that support STEM education and research and further engagement with the Puerto Rican community.

Funding

Total Obligations for Arecibo

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance (MPS)[2]	$2.42	$3.00	$3.00	-	-	-	-	-
Operations & Maintenance (GEO)[2]	6.72	3.00	3.00	-	-	-	-	-
Cleanup[3]	3.05	-	-	-	-	-	-	-
TOTAL	**$12.19**	**$6.00**	**$6.00**	**-**	**-**	**-**	**-**	**-**

[1] The current cooperative agreement ends on May 31, 2023; however an extension is planned through September 30, 2023. Beyond that NSF is negotiating a new contract for Site Maintenance.

[2] In FY 2024, NSF will transition from a cooperative agreement for operations of Arecibo Observatory to a contract for maintenance of the site.

[3] Supplemental for emergency cleanup of the Arecibo site of $3.05 million from GEO.

The FY 2024 Request of $6.0 million includes support for the site maintenance contract and transition costs. Funding for the proposed ACSER initiative would come from EDU and is not shown in the table above. Based on historical cost data, we anticipate the site maintenance contract will require annual funding of approximately $2.25 million, which will be divided equally between the MPS and GEO Directorates. Additional funds to cover potential transition costs are included in the FY 2024 Request. If awarded, EDU would fund the potential ACSER program at $1.0 million annually for five years.

Reviews and Reports

In mid-2021, NSF organized the Arecibo Observatory Options Workshop to engage the community in exploring novel ideas for future scientific, educational, and cultural activities at Arecibo. This workshop focused on finding innovative ways to create or enhance opportunities for activities and public outreach at the site. Participants from universities, colleges, and non-academic organizations (such as museums) in Puerto Rico were particularly encouraged to contribute. Participants presented a variety of scientific options as well as some innovative and creative educational and STEM workforce development concepts.

The 2020 Decadal Survey of Astronomy and Astrophysics (Astro2020)[1], released in November 2021, pointed out that much of the radio astrophysics relevant to the Astro2020 goals that was lost because of the collapse of the 305-meter telescope can be recovered through additional investment in existing facilities, and through international partnerships. The report noted that "there is a groundswell of local support for efforts to preserve the site for educational and cultural activities even if not for research" and "Astro2020 supports its continuation as an important nexus for education, community, and developing a diversified STEM workforce."

[1] www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020

Renewal/Recompetition/Disposition

After review of community input and extensive internal consideration, NSF decided not to renew the cooperative agreement with the current awardee, given that the terms of that award were based on operations of the 305-meter telescope, which collapsed in December 2020 and is no longer functional. Support for the site will transition to a contract that will maintain the site on behalf of NSF, providing a flexible foundation for future initiatives such as the potential ACSER center as well as other scientific research and educational efforts. This plan will ensure that the site of Arecibo Observatory will continue to be a vibrant center for multidisciplinary research and education.

GEODETIC FACILITY FOR THE ADVANCEMENT OF GEOSCIENCE (GAGE)
www.earthscope.org/about/gage-sage-facilities/

Geodetic Facility for the Advancement of Geoscience Funding
(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Change over FY 2023 Estimate Base Percent
$13.94	$14.55	$15.18	$0.63	4.3%

Brief Description

The Geodetic Facility for the Advancement of GEoscience is a distributed, multi-user facility that enables a diverse research community to make advances in understanding Earth processes that would otherwise not be possible, through broad access to geodetic instrumentation, field training and support, and data services. GAGE operates networks of Global Positioning System (GPS) and Global Navigational Satellite Systems instruments; provides geodetic and related geophysical instrumentation for field experiments; supports data archiving, quality control, and distribution; and provides education and outreach activities that serve a wide range of audiences.

Meeting Scientific Community Needs

To serve the research needs of the broad Earth science community, GAGE is organized under three primary service areas: Geodetic Infrastructure, Geodetic Data Services, and Education and Community Engagement. GAGE users can access data and educational products via the internet at no cost. Scientists making use of equipment, training, and other resources provided by GAGE typically are funded via awards from NSF, the U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), and other agencies. NSF-sponsored users are generally supported by the Division of Earth Sciences (EAR), the Division of Ocean Sciences (OCE), and OPP. GAGE's ongoing operations and maintenance of continuous GPS regional networks, deployment of portable geodetic instruments, and provision of data enables researchers to address major Earth science questions.

Demand for data, equipment, and other resources provided via GAGE remains high. In FY 2022, data from the facility was downloaded by over 80,000 unique IP addresses. Field experiments using equipment and field engineering assistance continue at an average annual level of approximately 100 projects. GAGE also facilitates three different summer internship programs at the community college, undergraduate, and graduate school levels that primarily focus on students from groups that are underrepresented in geosciences. These programs have consistently produced scientific and professional benefits for the participating students by advancing knowledge and awareness of geoscience career paths as indicated in pre- and post-participation survey results. Interns also enhanced their computational and scientific communication skills.

Status of the Facility

GAGE is currently operating in year five of a seven-year NSF award, and the capabilities provided by the facility have evolved based on input from a series of community engagement activities, including

an NSF-sponsored workshop entitled "Future Seismic and Geodetic Facility Needs in the Geosciences", held in 2015.[1] EAR continues to evaluate NSF's geophysical facilities to best enable emerging research directions. In 2018, EAR commissioned a National Academies of Sciences, Engineering, and Medicine decadal survey that identified top research priorities for the Earth sciences for the next decade. Released in July 2020, *A Vision for NSF Earth Sciences 2020-2030: Earth in Time*[2] reaffirmed the importance of NSF's geodetic and seismic facilities in advancing Earth science research over the next decade.

As part of the decadal survey process, a workshop entitled *Management Models for Future Seismological and Geodetic Facilities and Capabilities* was held to review the strengths and weaknesses of different management models for NSF geophysical facilities.[3] Following the release of the workshop report, EAR announced that, at the time of the next competition for their management and operations, the current Seismological Facility for the Advancement of GEoscience (SAGE) and GAGE facilities would be consolidated into a single facility with a single operator.[4]

In FY 2020, GEO commissioned a portfolio review from a subcommittee of its Advisory Committee to inform planning for the future, consolidated geophysical facility. The group reviewed possible geophysical instrumentation and sensor networks that a new facility might support to address the science priorities highlighted in the decadal survey. Additionally, the portfolio review report, which was completed in FY 2021, emphasized the importance of developing partnerships in support of elements of SAGE and GAGE that are mission critical for other Federal agencies. EAR is working to define the best path forward for a future facility and is undertaking efforts to expand existing federal partnerships.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is provided by EAR, working cooperatively with OPP, the Office of the General Counsel, the Office of Legislative and Public Affairs, and the Office of Budget, Finance, and Award Management (BFA). Within BFA, the Large Facilities Office advises program staff and assists with agency oversight. The GEO facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

The GAGE facility awardee is a 501(c)(3) nonprofit corporation governed by a Board of Directors elected by institutional representatives. As of January 1, 2023, UNAVCO, which managed GAGE since the start of the current award in FY 2018, and the Incorporated Research Institutions for Seismology (IRIS), Inc., merged to form the EarthScope Consortium, Inc., with over 170 institutional members. This consortium now manages both GAGE and SAGE as discrete major facilities. Board members vet program decisions associated with GAGE management and operation through consultation with EarthScope Consortium staff and GAGE advisory committees.

[1] www.iris.edu/hq/files/workshops/2015/05/fusg/reports/futures_report_high.pdf

[2] www.nap.edu/catalog/25761/a-vision-for-nsf-earth-sciences-2020-2030-earth-in

[3] www.nap.edu/catalog/25536/management-models-for-future-seismological-and-geodetic-facilities-and-capabilities

[4] www.nsf.gov/pubs/2020/nsf20037/nsf20037.jsp

Partnerships and Other Funding Sources

The GAGE facility is primarily supported by EAR with additional support provided by OPP. NASA funding for GAGE enables satellite orbit and clock corrections and the refinement of the International Terrestrial Reference Frame. USGS provides support for ShakeAlert, its earthquake early warning program. EarthScope Consortium also leverages the GAGE award to partner with commercial entities that use the data for autonomous vehicle navigation.

Funding

Total Obligations for GAGE

(Dollars in Millions)

				ESTIMATES[1]				
	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$13.94	$14.55	$15.18	$16.50	$16.50	$16.50	$16.50	$16.50

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends in September 2025. In 2020, NSF announced preparation for a competition for a future single, unified geophysical facility as the successor to GAGE and SAGE.

NSF is currently implementing recommendations from the research community and prior facility reviews, that include innovations in multi-constellation instrumentation for more precise measurements of Earth's surface and to improve studies of near-surface processes (e.g., water storage and flux); moving data services for the facility to the cloud; and recapitalizing aging instrumentation. EAR is evaluating different strategies to address aging instrumentation and plans to phase in recapitalization over the current GAGE award period.

Reviews and Reports

NSF externally reviews components of the GAGE facility on an annual basis. In 2022, NSF conducted a review of the GAGE Education and Community Engagement activity, which was described by reviewers as "unparalleled and impactful" and having "an outsize[d] influence on Earth-sciences culture". NSF conducted a full management review of GAGE in September 2021, and the panel commended UNAVCO for its strong overall performance in operating and maintaining GAGE. NSF will conduct a follow-up review of the full facility in 2023.

Renewal/Recompetition/Disposition

In 2020, NSF announced preparation for a competition for a future single, unified geophysical facility as the successor to GAGE and SAGE. NSF plans to evolve components of GAGE and SAGE through the competition for the future facility to enable advances in the scientific priorities established by the *Earth in Time* decadal survey. NSF is considering the recommendations in the portfolio review to formulate a strategy for continued support of this important community research resource. Disposition is not being considered at this time.

While the GAGE award was initially planned to end in 2023, NSF announced in June 2021 that it would extend the current awards for operations of both SAGE and GAGE to ensure continuity of services until 2025. This extension will allow NSF to work with agency partners to thoughtfully respond to the recommendations in the portfolio review.

ICECUBE NEUTRINO OBSERVATORY (ICNO)
Icecube.wisc.edu

IceCube Neutrino Observatory Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base	
			Amount	Percent
$7.26	$7.66	$8.01	$0.35	4.6%

Brief Description

The IceCube Neutrino Observatory cubic-kilometer detector was designed to observe neutrinos from the most violent astrophysical sources in the Universe. Neutrinos—almost massless particles with no electric charge—can travel from their sources to Earth with essentially no attenuation and no deflection by magnetic fields. ICNO is the world's largest high-energy neutrino detector, comprising 5,160 digital optical modules (DOMs) deployed deep within the ice cap under the U.S. Amundsen-Scott South Pole Station in Antarctica. The facility will continue to evolve in its scientific mission as 700 DOMs are added in the coming years.

ICNO has delivered world-leading scientific results—from measuring previously unexplored atmospheric neutrino oscillations to observing cosmic neutrinos with energies exceeding 10 peta-electron volts. In 2013, ICNO observed the first high-energy cosmic neutrinos—key messengers revealing an unobstructed view of the Universe at wavelengths where it is opaque to photons. In 2017, new data obtained by ICNO revealed clues to the origins of high-energy cosmic rays, by tracing the path of a very high-energy neutrino back to a previously known but little-studied blazar—the nucleus of a giant galaxy that fires off massive jets of elementary particles, powered by a supermassive black hole at its core. These discoveries have established ICNO's role in multi-messenger astrophysics for observing the extreme Universe.

Meeting Scientific Community Needs

While the evidence of the first known source of high-energy neutrinos and cosmic rays is compelling, more data are now sought from similar or other sources. The ICNO results opened a new window to the Universe, providing novel insights into the engines that power active galactic nuclei and generate high-energy cosmic rays, gamma ray bursts, and other violent and energetic astrophysical processes. ICNO's exploration of scientific frontiers has already changed and expanded our understanding of the Universe.

Inquiries are underway concerning science questions that may arise from the study of neutrino properties, especially at the lower energies to which ICNO's Deep Core strings have enabled access. For example, to fill in the blanks of the Standard Model of particle physics, scientists have been determining properties of the known types of neutrinos and conducting diligent searches for a hypothesized particle known as the "sterile neutrino." In 2022, for the first time, ICNO scientists proved that *electron antineutrinos* are present in the ICNO data, as well as found evidence of high-energy neutrino emission from a remote active galaxy.

More than 350 physicists from 58 institutions in 14 countries make up the IceCube Collaboration. Of these, about 150 are U.S. scientists supported by OPP and the MPS Division of Physics (PHY). This international team is responsible for the ICNO scientific program, and many of the collaborators contributed to the design, construction, and operation of the detector. The ongoing upgrade of the detector will extend ICNO's overall sensitivity to a lower energy range, which will provide a bridge to studies at other neutrino observatories such as the Super-Kamiokande detector in Japan and other similar (much smaller than IceCube) detectors across the world. The ICNO upgrade will also provide enhanced calibration capabilities to improve the pointing of neutrino events to astrophysical sources and improve the existing 12-year data set.

Status of the Facility

The ICNO year-around operation includes two staff members who carry out "winter-over" duties at the South Pole where the ICNO data are collected and transmitted daily to the University of Wisconsin-Madison (UW-M). These data are then processed and served to the IceCube Collaboration. The summer crew is typically five to six members who complete more extended maintenance activities. A midscale research infrastructure award was issued in 2019 to upgrade ICNO's Deep Core Array with about 700 new digital sensors that will significantly improve measurements of lower-energy neutrino properties. As neutrinos travel through space, they change from one type to another—a quantum mechanical process known as neutrino oscillation. The ICNO Upgrade is intended to provide the first precision measurements of the number of *tau* neutrinos appearing due to these oscillations.

During the COVID-19 pandemic, limitations on the number of personnel who could be deployed to Antarctica restricted the ICNO staffing. These crew size limitations have resulted in a three-year delay to the upgrade project, which was originally targeted to be completed in FY 2023. A new project baseline is now in place extending the upgrade project to be completed in FY 2026.

Governance Structure and Partnerships

NSF Governance Structure

The ICNO facility is managed at NSF by an Integrated Project Team composed of staff from OPP, MPS, the Large Facilities Office, and the Division of Acquisition and Cooperative Support. The GEO facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

The ICNO facility is governed by UW-M and its sub-awardee institutions: University of Maryland College Park, University of Delaware, Michigan State University, Pennsylvania State University, University of Alabama, and Lawrence Berkeley National Laboratory. The ICNO data are used by a broad science collaboration, currently consisting of 58 institutions in 14 countries in Europe, Asia and Oceania.

Partnerships and Other Funding Sources

Operation of ICNO in support of scientific research began in FY 2011. The associated costs are, and will continue to be, shared by the partner funding agencies (NSF and non-U.S.) roughly in proportion to the number of Ph.D. researchers involved in the O&M activities (55 percent U.S. and 45 percent non-U.S. in 2022). The NSF support for O&M, research, and education and outreach is shared by OPP (lead) and PHY, as well as by other in-kind contributions from participating institutions. The work in

support of facility operations is performed by students, postdocs, and senior researchers, who are also participating in research using the data produced by ICNO.

Funding

Total Obligations for ICNO
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations and Maitenance (GEO)	$3.66	$3.83	$3.99	$4.15	$4.60	$4.60	$4.60	$4.60
Operations and Maitenance (MPS)	3.60	3.83	4.02	4.15	4.60	4.60	4.60	4.60
TOTAL	**$7.26**	**$7.66**	**$8.01**	**$8.29**	**$9.20**	**$9.20**	**$9.20**	**$9.20**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends March 2026.

O&M support for ICNO is estimated at approximately $8.01 million in FY 2024. This is a 4.6 percent increase over the FY 2023 Estimate reflecting inflation and the higher cost of operations.

Reviews and Reports

The previous cooperative agreement with UW-M required reviews of the ICNO O&M activities after the second and fourth project years. The mid-term O&M panel review was held in March 2019, and the second, NSF staff "site visit" review was held virtually in March 2020. These reviews found that ICNO continues to be a very important element of the OPP and PHY programs, rated the O&M activities as excellent, and recommended continuing operation of ICNO for the remaining period of the previous award.

With the severe COVID-19 pandemic impacts to the U.S. Antarctic Program operations, the ICNO Upgrade project was halted, and its re-baselining options were thoroughly reviewed in 2021 and 2022. Based on these reviews, the completion of the upgrade project was extended to FY 2026.

Renewal/Recompetition/Disposition

Full operation of ICNO began in 2011 with an anticipated detector lifetime of 25-30 years. In anticipation of the ICNO O&M support cycle completion in 2021 and according to internal NSF guidance, an O&M renewal proposal was solicited from ICNO leadership. The proposal was received in Summer 2020 and fully reviewed according to NSF standard practices. In April 2021, the ICNO O&M Cooperative Agreement with UW-M was renewed for the next five years, 2021-2026.

Currently there are no plans for divestment of this facility.

INTERNATIONAL OCEAN DISCOVERY PROGRAM (IODP)
http://iodp.tamu.edu/index.html and https://iodp.org

Integrated Ocean Discovery Program Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$51.70	$50.40	$52.77	$2.37	4.7%

Brief Description
The drillship *JOIDES Resolution (JR)* represents NSF's primary contribution to the International Ocean Discovery Program (IODP). The *JR* is a deep-ocean drilling vessel whose scientific operations are procured for NSF by means of a long-term lease held by the *JR* Science Operator (JRSO), Texas A&M University. Besides NSF, the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan and the European Consortium for Ocean Research Drilling (ECORD) continue to provide drilling platforms to IODP.

Meeting Scientific Community Needs
IODP began in FY 2014 as the replacement for the Integrated Ocean Drilling Program, which succeeded the Ocean Drilling Program. IODP represents an international partnership of scientists, research institutions, and funding organizations of 22 nations that collect geologic data and samples from beneath the ocean floor. IODP explores Earth's evolution and structure as recorded in the ocean basins. IODP platforms provide sediment and rock samples (cores), *in situ* monitoring, measurements from borehole observatories, shipboard and shore-based descriptive and analytical facilities, downhole geophysical and geochemical measurements (logging), and opportunities to conduct experiments to determine *in situ* conditions beneath the sea floor.

A comprehensive online survey of the U.S. science community was undertaken by the United States Science Support Program (USSSP) in 2016 and 2017 to assess the success of the *JR* in meeting the needs of the IODP Science Plan. This survey received 876 responses and led to 81 scientists convening for the *JR* Assessment Workshop to distill and analyze these survey responses, examine the science results of FY 2014-2017 *JR* operations, and make recommendations to NSF regarding whether the *JR* was still needed to address the remaining objectives of the ten-year science plan. The report states: "the survey results underscore the scientific community's deep satisfaction with the *JOIDES Resolution* and its ability to continue to fulfill IODP objectives."

Status of the Facility
After numerous international workshops in CY 2019, in October 2020, the IODP community released a new science plan entitled *2050 Science Framework for Scientific Ocean Drilling.*[1] This plan guides multidisciplinary sub-seafloor research into interconnected processes that characterize the complex Earth system and shape our planet's future. The *2050 Science Framework* has a 25-year outlook, requiring state-of-the-art approaches for scientific ocean drilling to achieve its objectives into the mid-21st century.

[1] www.iodp.org/2050-science-framework

The award with Texas A&M University supports facility operations through FY 2024. The current Environmental Impact Statement for the JR expires in 2028.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is provided by a program officer in the GEO Division of Ocean Sciences (OCE), who works cooperatively with staff from Office of Budget, Finance, and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. The GEO facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

The JR Board, one of three IODP governing bodies, is chaired by a U.S. scientist, with participation by NSF, other contributing international funding agencies, community scientists, and the facility operator. The Board provides operational and management oversight of (1) the *JR* (via the operator—Texas A&M University), (2) the Science Support Office, and (3) the *JR* Facility Advisory Panels. The Board also approves annual program plans and decides on ship tracks on behalf of IODP; NSF decides whether to accept these plans in executing its fiduciary and legal authority for the operation of the *JR*.

Partnerships and Other Funding Sources

IODP participants include the U.S., Japan, ECORD, the People's Republic of China, India, Australia, and New Zealand, with all participants except Japan providing financial contributions to the *JR* operations. Japan provides program support through substantial investment in operations of the heavy drill ship *Chikyu*, with U.S. and Japanese scientists enjoying reciprocal rights on each drilling vessel.

Funding

Total Obligations for IODP

(Dollars in Millions)

		FY 2023		**ESTIMATES**[1]				
	FY 2022	Estimate	FY 2024					
	Actual	Base	Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$51.70	$50.40	$52.77	$52.77	$52.77	$52.77	$52.77	$52.77

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends in September 2024.

The FY 2024 Request includes $52.77 million for IODP. The increase above FY 2023 is primarily associated with inflationary increases in drilling equipment, supplies, and other operational costs.

Reviews and Reports

An external mid-award review panel was convened by NSF in July 2022 to examine facility performance. Excerpts from the panel summary follow: "The JRSO facility is vital to the marine geoscience community…The JOIDES Resolution is in remarkable condition. The physical facility (ship and instruments) and human resources currently provided through the JRSO … is spearheading the implementation of innovative measurements, curation (cores and data), computing, publications, and training the next generation of scientists and technical innovators. The (IODP) program … is working remarkably well and is addressing the current science plan as well as key elements of the 2050

Scientific Framework…"

Renewal/Recompetition/Disposition
After NSB authorization and the NSF Director's approval, the current award was renewed for an additional five years of operation from FY 2020 through FY 2024. After following its internal processes and careful consideration, NSF has decided not to renew the award for IODP O&M. NSF is actively engaging the scientific community regarding the future of scientific ocean drilling.

LARGE HADRON COLLIDER (LHC) – ATLAS AND CMS
https://home.cern/science/accelerators/large-hadron-collider

Large Hadron Collider Funding
(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$21.51	$20.50	$20.50	-	-

Brief Description

The LHC, operated by the European Organization for Nuclear Research (CERN) in Geneva, Switzerland, is the world's most powerful particle accelerator. It produces the highest energy particle beams ever created in a laboratory, making it the premier facility in the world for research in elementary particle physics. The LHC is a superconducting accelerator ring approximately 16.5 miles in circumference, in which counter-circulating proton beams can collide with a total energy of up to 14 TeV (one TeV=10^{12} electron volts). The collisions occur at four discrete interaction points around the circumference of the accelerator where highly sophisticated detectors measure the characteristics of the debris produced in the proton-proton collisions. The LHC can also collide beams of heavy ions, such as lead.

The discovery of the Higgs boson in 2012—one of the original goals of the LHC—is one of the most important particle physics discoveries of the last 50 years. Now the scientific focus has shifted to understanding the detailed properties of the Higgs boson and other known processes to elucidate possible deviations from current theory—deviations that might indicate new phenomena.

This search for new phenomena motivates the High Luminosity (HL) upgrades to the LHC and its detectors, which will increase the proton collision rater, resulting in a much larger data sample. As part of a global effort, NSF is supporting upgrades to two LHC detectors to enable collection and analysis of the HL-LHC data.[1]

Meeting Scientific Community Needs

The FY 2024 Request will support studies using two large general-purpose detectors: A Toroidal LHC ApparatuS (ATLAS) and the Compact Muon Solenoid (CMS), to record and analyze the by-products of proton-proton and heavy ion collisions. Measurements made by the detectors will probe the fundamental structure of matter to elucidate the basic forces that have shaped our Universe since the beginning of time and that will determine its fate. Priority areas of interest to researchers are the search for new physical phenomena not described by the Standard Model of Particle Physics (such as new particles or forces), extra spatial dimensions, and experimental evidence for Dark Matter.

Currently, more than 1,200 U.S. researchers participate in the ATLAS and CMS collaborations, including more than 100 post-doctoral fellows and more than 400 students, about half of whom are undergraduates. The U.S. researchers comprise about 20 percent of the total membership of the

[1] See the HL-LHC narrative in the MREFC chapter for more information.

ATLAS and CMS collaborations. NSF supports about 20 percent of the U.S. ATLAS and U.S. CMS contingents (plus about 30 of the nearly 1,300 members of the LHCb collaboration, which operates the separate, specialized LHCb experiment at LHC). Research at LHC is supported by NSF through the Elementary Particle Physics and Nuclear Physics programs within the Division of Physics (PHY).

In addition, a world-wide cyber infrastructure effort, the Worldwide LHC Computing Grid (WLCG), is dedicated to LHC data processing, allowing scientists to remotely access and analyze vast data sets. The U.S. ATLAS and U.S. CMS collaborations continue to lead the development and exploitation of distributed computing within their respective international collaborative efforts. The WLCG Tier 1 and Tier 2 computing centers (funded by DOE and NSF, respectively) enable the researchers at 98 U.S. universities and five national laboratories to access LHC data and computing resources and thus train students in both state-of-the-art science and computational techniques.

Status of the Facility

The LHC is the only experimental particle physics facility operating at the high energy frontier. The facility and the planned HL-LHC upgrades are a high priority of the entire high energy physics community. The 2015 LHC energy upgrade from 8 TeV to 13 TeV pushed the boundaries of our understanding into unknown territory. CERN is carrying out a multi-year program to increase the beam interaction rate that will culminate with HL-LHC operation beginning in 2029. This will produce a very large data sample of rare events that could shed light on new physics as researchers look for discrepancies between precision measurements and theoretical predictions.

Installation of smaller-scale detector upgrades, completed in 2021, have prepared the ATLAS and CMS detectors for the current cycle of accelerator operations, which started in April 2022. These upgrades will enable ATLAS and CMS to keep pace with LHC's performance enhancements through 2026. In January 2022, reacting to pandemic impacts on the HL-LHC upgrade schedule and on the individual funding agencies participating in the upgrades, CERN announced a one-year delay to the start of installation of the HL-LHC accelerator and detector components, moving the end date of the current operations cycle from January 2025 to January 2026. They additionally announced an extension in the installation period to three full years—through the end of calendar year 2028 (rather than the two and one-half years that had been previously planned). This three-year shutdown will enable the installation of major upgrades to the accelerator and detectors preparatory to ten years of HL-LHC operation, extending the scientific reach of the facility.

In June 2022, the CERN Council announced its intent to end cooperation with Belarus and Russia (in June and December 2024, respectively) in response to Russia's ongoing aggression against Ukraine. Impacts of this announcement are still being evaluated. Also, in light of the European energy supply and cost crisis, CERN will take actions to reduce its energy consumption. CERN closed operations two weeks early in late 2022 and will scale back accelerator operations by 20 percent in 2023. CERN is working on plans to run the accelerator during 2023 under conditions that may at least partially offset the reduced running time and minimize the impact on science.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is led by a program officer in MPS PHY, who works cooperatively with staff from BFA,

the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice and assists with agency oversight and assurance. The MPS facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

NSF/PHY staff and their Department of Energy (DOE) Office of Science counterparts meet twice yearly with CERN and funding agencies from other nations at Resource Review Board meetings, where technical and financial issues are discussed and decided. The ATLAS and CMS experiments are each funded by more than 40 different agencies, including NSF and DOE. NSF and DOE coordinate U.S. investments in the LHC program through a Joint Oversight Group (JOG).

Partnerships and Other Funding Sources

U.S. activities at CERN are enabled by a DOE/NSF/CERN agreement signed in 1997 ("Experiments Protocol I") and a Cooperation Agreement signed in May 2015 and renewed every five years. An additional agreement signed in December 2015 ("Experiments Protocol II") further defined the framework for NSF participation in the ATLAS and CMS detector collaborations to include continued participation during the HL-LHC era.

Funding

Total Obligations for LHC

(Dollars in Millions)

				ESTIMATES[1]				
	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$21.51	$20.50	$20.50	$20.50	$20.50	$20.50	$20.50	$20.50

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends December 2026 (CMS) and January 2027 (ATLAS).

NSF supports detector operation through two awards—one to the University of Nebraska-Lincoln for CMS, and another to Stony Brook University for ATLAS – shown in aggregate above. Annual operations and maintenance funding covers the costs of NSF-provided detector components, software and computing, and contributions to a common fund to maintain shared detector infrastructure. Detector operation and maintenance are projected to require future levels of effort similar to those needed to support the current apparatus. Data handling is an exception, in which extraordinary efforts by CERN, the experiment collaborations, and funding agencies are now underway on a global scale to support HL-LHC operation and the greater volume of data that will be collected beginning in 2029.

Reviews and Reports

NSF and DOE conduct separate and joint external reviews of operations and detector upgrade activities. Each agency is fully cognizant of the activities of the other partner, and recommendations from reviews are routinely used to inform ATLAS and CMS operations planning and the agencies' oversight thereof. Two JOG review meetings per year assess operational performance, scientific and financial status, management issues, and plans for future activities. DOE and NSF conducted joint external panel reviews of ATLAS and CMS operations at the end of January 2022. The most recent JOG

revies was held in October 2022 and the next one is planned for March 2023.

Renewal/Recompetition/Disposition

NSF awarded operations funding to CMS and ATLAS through five-year cooperative agreements beginning in FY 2022, with current awards expiring in December 2026 and January 2027, respectively. The ATLAS award was a renewal of the prior five-year award. The CMS award was to a new awardee. The awards were implemented after NSF completed a proposal-driven review process that included external review and cost analysis of each detector's operations proposal. NSF has no ownership of any part of the facility. CERN has taken responsibility for disposal of all irradiated apparatus at the conclusion of experimental activity. No disposition is planned at this time.

LASER INTERFEROMETER GRAVITATIONAL-WAVE (LIGO)
www.ligo.caltech.edu

Laser Interferometer Gravitational-Wave Observatory Funding
(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$45.00	$45.00	$50.00	$5.00	11.1%

Brief Description

Monitoring millisecond changes in the geometry of space-time using kilometer-scale laser interferometry, LIGO can map the rippling gravitational traces of energetic and violent events such as the coalescence of neutron stars and black holes. LIGO also searches for other sources of gravitational radiation due to phenomena such as the wobbling of fast-spinning neutron stars, vibration of cosmic strings, supernova explosions, and possibly the Big Bang itself. LIGO comprises two main sites, one in Livingston Parish, Louisiana and one in Hanford, Washington. At each site, an L-shaped vacuum chamber with two four-kilometer-long arms joined at right angles houses an optical interferometer. The interferometers are used to measure minute relative changes in the distances between mirrors at the ends of the arms that are caused by a passing gravitational wave (GW). The predicted distortion of space caused by a GW from a likely source is about one part in 10^{21}, meaning that the expected length change over a four-kilometer distance is only about 1/1000th the diameter of a proton.

Meeting Scientific Community Needs

LIGO, the most sensitive GW detector ever built, leads the expanding worldwide effort to study the cosmos through the direct observation of gravitational radiation. LIGO's four-kilometer length was chosen to make the expected signal as large as possible within terrestrial and financial constraints: longer arms would result in a bigger signal but would entail larger construction costs. Looking for coincident signals from the two widely separated sites enhances LIGO's ability to discriminate between a GW and local sources of noise.

LIGO has had two significant historic accomplishments: the direct detection of GWs arising from the collision and coalescence of a pair of black holes (2015), and the detection of the GW signal arising from the collision of two neutron stars (2017). The latter enabled subsequent observations of the GW source by more than 70 telescopes around the world, which significantly added to our understanding of the mechanisms by which heavy elements are produced. The 2017 Nobel Prize in Physics was awarded to LIGO pioneers Barry C. Barish, Kip S. Thorne, and Rainer Weiss "for decisive contributions to the LIGO detector and the observation of gravitational waves." In total, LIGO has observed more than 90 GW candidate sources.

The LIGO Scientific Collaboration (LSC), an open collaboration that organizes the major international groups doing LIGO-related research, has more than 120 collaborating institutions in 19 countries with more than 1,400 participating scientists. The LSC helps to establish priorities for scientific operation, carries out data analysis and validation of scientific results, and contributes to improvements in

instrumentation at the LIGO facilities. Additionally, LSC members explore future technologies and participate with LIGO in activities that promote STEM education and public outreach programs. NSF supports LSC activities in the U.S. at a level of nearly $10 million per year through regular disciplinary program funds.

Status of the Facility

The broader scientific community is eager for more GW detections. LIGO's GW detection rate scales as the third power of its sensitivity, so LIGO prioritizes efforts aimed at improving performance over operation for extended observing periods. Efforts are underway at both LIGO sites to lead and coordinate the technical efforts intended to improve interferometer sensitivity.

LIGO conducted a third observational run, begun in April 2019 and lasting about 11 months, at about 80 percent of the estimated design sensitivity of the interferometers. LIGO researchers are now working to remediate those limitations. They have also installed new elements that will further enhance the sensitivity of the apparatus when LIGO's fourth year-long observational run begins in May 2023. These new elements are expected to boost LIGO's sensitivity by at least 25 percent compared to the third observing run.

During periods of observation, LIGO issues public alerts when it detects candidate GW events, reaching a vast and growing cadre of ground- and space-based observatories that are primed to make follow-up electromagnetic observations. Simultaneous observations by the two LIGO interferometers and Virgo (a GW detector located outside of Pisa, Italy, and funded by the Italian and French governments) enables localization of GW sources on the sky so that they can be observed by conventional telescopes at optical, radio, and other wavelengths. This has opened a new era of multi-messenger astronomy, where the synthesis of complementary information obtained from gravitational and electromagnetic observations is leading to powerful new insights about astrophysical phenomena. Many other NSF-funded electromagnetic observatories are crucial participants in this observational community.

Virgo and the Kamioka Gravitational Wave Detector (KAGRA) are foreign-led efforts that, like LIGO, are intended to directly observe GWs. Virgo will have a sensitivity of about two-thirds that of LIGO. KAGRA—a more ambitious, but technically challenging effort in Japan—may result in an even more sensitive apparatus (due to its location deep underground and its pioneering use of cryogenic optics), although the timescale for completion is at least a few years off. Virgo participated in joint observing during LIGO's third observing run, at a sensitivity about half that of LIGO's. KAGRA also participated in the end of run three in 2020, albeit at very modest sensitivity. Both detector groups plan to participate with LIGO in the fourth observing run, currently planned for Q3 2024.

Other efforts complement LIGO's capabilities by searching for GWs in frequency bands outside LIGO's sensitivity range (roughly 0-1000 Hz). NANOGrav (a U.S.-Canadian effort supported by NSF), along with similar efforts in Europe and Australia, is now searching for GW signals in the roughly nano-Hz to micro-Hz band. However, the expected global network of two U.S. LIGO sites, plus Virgo, KAGRA, and the anticipated LIGO-India facility (to be constructed and operated by the Government of India using interferometer components contributed by NSF) is the only experimental avenue for measuring GW source locations with sufficient angular resolution to allow complementary electromagnetic observations.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is led by a program officer in the MPS Division of Physics (PHY), who works cooperatively with staff from BFA, the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice and assists with agency oversight and assurance. The MPS facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

LIGO is managed by the California Institute of Technology under a cooperative agreement with NSF. A subaward to the Massachusetts Institute of Technology supports a team of scientists and engineers that is fully integrated into all LIGO activities. The LIGO management organization coordinates significant involvement by the user community, represented by the LSC, and arranges collaborative activities with other major GW detector activities in Asia, Europe, and Australia. External review committees organized by NSF help provide oversight through annual reviews.

Partnerships and Other Funding Sources

Advanced LIGO is a completed $205.0 million project that supported the development and installation of interferometer components and computing hardware that increased LIGO's sensitivity by about a factor of eight. The United Kingdom (UK), Germany, and Australia provided components and services to the Advanced LIGO project valued at about $20.0 million.

A+ is a further upgrade that is partially complete. NSF awarded $20.47 million during FY 2018-FY 2019 to complete final designs and construct the A+ upgrade. The UK is contributing about 10 million British Pounds and additional key hardware and effort are being provided through in-kind contributions from Australia. Some of the A+ enhancements were installed during 2022 and will be operated during the fourth observing run. Realization of the full A+ capability (roughly a two and half fold increase in sensitivity over Advanced LIGO) is planned during LIGO's multi-year fifth observing run, which is tentatively planned for 2025-2028.

LIGO-India would be constructed through a transfer to India of Advanced LIGO components, valued at approximately $50.0 million, which were originally intended as a second Hanford interferometer. This transfer would enhance the source localization capabilities of the global GW network. NSF signed a Memorandum of Understanding with India's Departments of Atomic Energy and Science and Technology in March 2016, agreeing to partner in this undertaking. The formal start of construction is pending approval by the Government of India Cabinet.

Funding

Total Obligations for LIGO

(Dollars in Millions)

				ESTIMATES[1]				
	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$45.00	$45.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends on January 2024.

LIGO operation and maintenance is entirely supported by NSF, which is requesting $50.0 million for FY 2024. The FY 2024 budget increase is primarily due to increases in labor and material costs, and infrastructure investments needed to extend the operating life of the buildings and equipment at the Hanford and Livingston sites.

Reviews and Reports

Reviews of observatory operation are held annually. Special-purpose reviews using external expert panels have also been held as needed, examining topics such as LIGO's computing plans, ultra-high vacuum system needs, education and outreach planning, and long-term storage of the interferometer components set aside for possible deployment to India. The most recent annual review was held in February 2023. Recommendations from annual reviews are routinely used to inform LIGO's operations planning and NSF's oversight thereof.

Renewal/Recompetition/Disposition

NSF will implement a new five-year award for LIGO operations in January 2024. NSF's invitation to Caltech to submit a renewal proposal for LIGO operation was done in accordance with NSF policy that considered the implications for competing the management of LIGO in comparison to soliciting a renewal proposal from the current management entity. No disposition is planned at this time.

THE NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)
www.neonscience.org/

National Ecological Observatory Network Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$69.01	$71.71	$78.04	$6.33	8.8%

Brief Description

Funded and overseen by the Directorate for Biological Sciences, NEON is the first observatory of its kind, designed to foster and enable advances in the basic understanding of the complexities of life on Earth at a continental scale, building from organisms and populations to the biosphere, and over timescales from seconds to decades. Construction of the observatory was completed in 2019, and it is designed to operate for 30 years. The NEON infrastructure is distributed across the United States (including Alaska, Hawaii, and Puerto Rico) and includes 20 regional eco-climatic domains. NEON collects standardized observations of plants, animals, and biogeochemistry in the air, land, and water at 81 sites across these domains using three types of approaches: on-the-ground organismal sampling by trained professionals, measurements by automated instruments in the environment, and airborne remote sensing surveys. After the collection and processing of data from instrument and observational systems, NEON makes 182 data products available on a centralized data portal that is free for all to access and use. It also makes openly available data tutorials, code packages, and other resources that enable use of NEON data by scientists and the community at large.

Meeting Scientific Community Needs

Use of NEON data and assets is increasing as more data become available, and as the research community continues to diversify and grow. Use of site data, soil and other samples, and remote sensing data continues to expand. Research is supported through awards made by the Macrosystems Biology and NEON Enabled Science Programs, as well as other research programs across the Agency. The NEON Airborne Observation Platform (AOP) has been used to assess major fires and, in partnership with the National Aeronautics and Space Administration (NASA), has participated in the science development of the Hyperspectral Infrared Imager (HyspIRI) mission. Multiple NEON science presentations by funded researchers formed the corpus of continental-scale sessions at the 2022 Ecological Society of America meetings in addition to presentations at several other venues, such as the 2022 American Geophysical Union Fall Meeting. The number of presentations using Remote Sensing data continues to increase compared to previous years, spurred in large part by data from the three AOPs. To date, there are over 530 articles (125 in 2022) with publishing authors from 54 countries, and 14,000 associated citations using NEON data or infrastructure in a substantial manner. In 2022 a new synthesis center, the Environmental Data Science Innovation & Inclusion Lab (ESIIL), was launched that will rely extensively on NEON and other data resources. A key component of NEON's ability to empower STEM talent in the ecological research community is through strategic leveraging of NEON's vast geographical footprint to foster numerous high impact outreach and education activities. Moreover, NEON democratizes data access and enables research capability throughout the U.S., including in almost 40 percent of the EPSCoR States and at many minority serving

institutions.

Status of the Facility

Prior to the COVID-19 pandemic in 2020, data were being collected as planned at all 81 terrestrial and aquatic sites across the 20 eco-climatic domains. In the year prior to the onset of COVID-19, NEON staff supported 304 engagement events reaching over 8,400 individuals. Events included presentations, site tours, conferences, trainings and outreach through social media, and in-person and virtual workshops targeting a wide range of public and STEM audiences. The groups engaged during these events were from different educational and/or career stages (e.g., high school, undergraduate, graduate student, postdoctoral fellows, scientists in academia, agencies), diverse geographic areas within the U.S., and multiple demographic groups, including underrepresented groups and Minority Serving Institutions. Data collection in the ensuing year was compromised by restrictions imposed during the pandemic. Despite these adverse impacts, the overall trend shows an increase in the use of NEON data. To date, more than 500 publications (126 in 2022) have been produced that rely significantly on NEON data or NEON infrastructure. Furthermore, engagement activities, many of which transitioned to a virtual format during the pandemic, have also continued to increase. Currently, all 18 Domain Support Facilities and the NEON Headquarters in Boulder, Colorado, are fully open, with COVID-19 policies implemented when required. The changing status around COVID-19 is continuously monitored for potential impacts on regular maintenance and data continuity, especially in the gathering of biological samples, an important component of the Observational Systems data.

Governance Structure and Partnerships

NSF Governance Structure

Oversight of the NEON program resides within the Division of Biological Infrastructure (DBI) in BIO, which works cooperatively with BFA, the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. The BIO Office of the Assistant Director and the Chief Officer for Research Facilities also provide high-level guidance, support, and programmatic oversight.

External Governance Structure

Within the current managing entity, Battelle, the NEON Chief Scientist provides overall scientific leadership and serves as the Principal Investigator for the award. A Science, Technology, and Education Advisory Committee (STEAC), composed of members of the NEON user community, provides strategic guidance and advice to Battelle, and helps ensure that NEON will enable frontier research and education. The work of the STEAC is complemented by several Technical Working Groups, comprising over 170 science, education, and engineering experts, that advise Battelle on technical aspects of the project and other issues that have scientific, educational, engineering, or operational implications.

Partnerships and Other Funding Sources

Several federal agencies (NASA, the National Oceanic and Atmospheric Administration, the Department of Energy, the United States Forest Service, the Environmental Protection Agency, the United States Department of Agriculture, the National Park Service, the Bureau of Land Management, and the United States Geological Survey) provide significant in-kind services, including sites for

deployment of NEON infrastructure. Formal agreements have been signed with the European Union, including with the Integrated Carbon Observing System Ecosystem Thematic Center, Infrastructure for Analysis and Experimentation on Ecosystems, and the Czech Climate Change Research Center, and Australia's Terrestrial Ecosystem Research Network. Coordination with the above entities spans planning, design, construction, deployment, environmental assessment, data management, geospatial data exchange, cyberinfrastructure, research, and modeling. Nongovernment Organizations, including the Ecological Society of America, the American Geophysical Union, and the American Indian Higher Education Consortium are assisting to broaden the impact of NEON science and education to the next generation of scientists and educators.

Funding

Total Obligations for NEON

(Dollars in Millions)

		FY 2023						
	FY 2022	Estimate	FY 2024	**ESTIMATES**[1]				
	Actual	Base	Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$69.01	$71.71	$73.04	$73.04	$73.04	$73.04	$73.04	$73.04
Deferred Maintenance	-	-	5.00	-	-	-	-	-
TOTAL	**$69.01**	**$71.71**	**$78.04**	**$73.04**	**$73.04**	**$73.04**	**$73.04**	**$73.04**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends October 2023.

The NEON program in BIO provides all support for operations, which are estimated at approximately $73.04 million in FY 2024. Operations and maintenance support began in FY 2014. In August of 2017, a supplemental operations award was authorized.

Reviews and Reports

The planned 2021 annual review of O&M was replaced by the review of a supplemental proposal to extend Battelle's period of performance through October 31, 2023. This review was completed by an external panel of experts and focused on science outcomes enabled by the facility, responses to the pandemic, Battelle's cost performance, and the facility's cyberinfrastructure, resulting in an NSB-approved two-year extension to the active O&M award and facilitating the ongoing competition for the next O&M award that was delayed by the pandemic (see below). The 2022 annual review of O&M was conducted by a panel of external expert reviewers that focused primarily on migration of NEON data to the Google Cloud, sensor and instrumentation life-cycle management, and overall approaches to risk management across the facility. Progress against the annual program plan and towards implementation of review recommendations is also monitored by BIO via bi-weekly teleconferences, triannual interim operations reports, an annual report, and site visits as needed.

Renewal/Recompetition/Disposition

The current O&M award, extended with NSB authorization due to the COVID-19 pandemic, ends in October 2023. BIO is completing review of proposals submitted in response to solicitation NSF 21-603, with the expectation of issuing a new award for O&M of NEON in late FY 2023. There are currently no plans for disposition of the facility.

NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL)
https://nationalmaglab.org/

National High Magnetic Field Laboratory Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$38.91	$39.91	$38.57	-$1.34	-3.4%

Brief Description

NHMFL is the world's premier high-magnetic-field laboratory, featuring an extensive collection of unique magnet systems and comprehensive support services. The laboratory is an internationally recognized leader in magnet design, development, and construction, including the development of new high-field superconducting magnets. NHMFL offers its users consistent and reliable high magnetic fields, such as the 45-tesla continuous-field magnet, the 100-tesla non-destructive pulsed-field magnet, the 36-tesla magnet for Nuclear Magnetic Resonance, the highest-field superconducting magnet for Fourier Transform-Ion Cyclotron Resonance mass spectrometry (21 tesla), and the highest field for magnetic resonance imaging (MRI) studies of living animals (21.1 tesla). These unique facilities are available to thousands of users each year and help define and advance the science frontiers in many disciplines through measurements made with state-of-the-art resolution and accuracy. NHMFL is operated by a consortium of three institutions, each of which house NHMFL facilities: Florida State University (FSU), University of Florida (UF), and Los Alamos National Laboratory (LANL).

Meeting Scientific Community Needs

NHMFL is the only high magnetic field user facility in the U.S., and currently is the largest magnet laboratory in the world, providing the highest magnetic fields and necessary services for scientific research conducted by users from a wide range of disciplines, including physics, chemistry, biology, biochemistry, neuroscience, energy, and environmental sciences. The laboratory serves roughly 2,000 users annually, including senior investigators, postdoctoral researchers, and students, both domestic and international. The user base continues to grow, with about 20 percent each year being new users.

Research conducted by users of NHMFL covers topics that include quantum phenomena in many classes of materials; electron and nuclear spins of solid, molecular, and biological materials; the structure and dynamics of the macromolecular components of life; and properties and functionalities of various materials essential in energy production, storage, and use. Major scientific impacts result from research on quantum materials conducted by researchers using NHMFL magnets, allowing the creation, identification, and visualization of new and unusual quantum effects that lead to deeper understanding of quantum materials and enable the discovery of new ones. Over the last several years, NHMFL has contributed to major scientific accomplishments in superconductivity and the frontier field of topological materials.

NHMFL trains the next generation of scientists through direct support for postdoctoral scholars, graduate and undergraduate students, and by holding annual summer schools for junior scientists,

as well as through its user program. NHMFL is committed to increasing diversity in the STEM workforce, both at the facility and in the broader community, through a wide range of education, outreach, and mentoring programs. Its Center for Integration of Research and Learning reaches more than 10,000 K-12 students annually via classroom outreach and laboratory tours.

Status of the Facility

NHMFL includes seven high-magnetic field user facilities as well as a center for the development of materials for magnets, a division for advancing magnet technologies, and an education center. Each facility is built around unique magnetic-field capabilities and is supported by a world-class scientific and technical staff. The facilities of NHMFL are open to all scientists based on a competitive proposal review process.

In 2023, NHMFL will provide to NSF a formal Condition Assessment report across all three sites, accompanied by an Asset Management Plan, to inform NSF and the facility management of anticipated major and infrequent maintenance expenses that could cause a significant departure from the routine funding profile.

As part of the planning for the future of NHMFL, NSF has continuously obtained community input about science and technical opportunities for high magnetic fields. Community input has included the 2013 report by the National Academies of Sciences, Engineering, and Medicine (the National Academies), *High Magnetic Field Science and Its Application in the United States: Current Status and Future Directions*.[1] The report provided several recommendations with respect to specific scientific priorities for new magnet development. In direct response to one of these recommendations, NSF has provided funding[2] for the development and design of a 40-tesla all-superconducting magnet, capitalizing on recent advances in high-temperature superconducting-magnet technology. The 2013 report, alongside several other community reports, also highlighted the need to combine high magnetic fields with synchrotron facilities. To this end, NHMFL is partnering with the Cornell High Energy Synchrotron Source (CHESS) on the construction of a new High Magnetic Field Beamline (HMF) that will offer the highest currently available magnetic fields at any synchrotron facility in the world. The HMF project, led by Cornell University, is being implemented through an NSF Mid-scale Research Infrastructure Track 2 award.

A new National Academies study on the long-term opportunities for the Nation's high magnetic field science and technology development was initiated in 2022. The resulting National Academies report, anticipated in 2024, along with the outcomes of the facility condition assessment and progress of current NSF investments in the development of high-field magnets, will inform NSF's plans for leading NHMFL into a robust next-generation national facility based on new cost-effective and energy-efficient magnets.

[1] www.nap.edu/catalog/18355/high-magnetic-field-science-and-its-application-in-the-united-states

[2] Funding was provided through the NHMFL O&M award ($4.20 million in FY 2018) and through two separate awards: $4.20 million in FY 2020 for conceptual design from DMR and $15.82 million in FY2021 for final design from the Mid-scale Research Infrastructure Track 1 program.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is led by a program officer in the MPS Division of Materials Research (DMR) who works cooperatively with staff from the Division of Chemistry (CHE), the Office of Budget, Finance and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice and assists with agency oversight and assurance. The MPS facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

NHMFL is operated under a cooperative agreement by a consortium of three institutions: FSU, UF, and LANL. FSU, as the primary awardee, is responsible for administrative and financial oversight and for ensuring that laboratory operations are consistent with the cooperative agreement. The principal investigator, the NHMFL director, reports to the FSU Vice President for Research. The NHMFL director receives guidance primarily from the NHMFL executive committee, the NHMFL science council, and the NHMFL diversity committee, together with recommendations from an external advisory committee and the users' executive committee. In 2023, the NHMFL director is stepping down after a successful term, and FSU, in consultation with NSF, is undertaking a search for a new director.

Partnerships and Other Funding Sources

The State of Florida contributes approximately $12 million per year to support NHMFL. While there is no formal partnership at the federal agency level, the Department of Energy (DOE) supports NHMFL through LANL, which contributes approximately $2 million per year.

Funding

Total Obligations for NHMFL

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028
Operations & Maintenance (DMR)	$37.18	$36.18	$36.47	$37.03	$37.27	$38.05	$38.05
Operations & Maintenance (CHE)	1.73	2.10	2.10	2.10	2.10	2.10	2.10
Special Projects[2,3]	-	1.63	-	-	-	-	-
TOTAL	**$38.91**	**$39.91**	**$38.57**	**$39.13**	**$39.37**	**$40.15**	**$40.15**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends in December 2027.

[2] FY 2023 Special projects reflects funding for repairs and maintenance beyond regular O&M.

[3] Funding in FY 2023 and FY 2024 does not include potential additional funding that may be provided by MPS' Office of Strategic Initiativ (formerly Office of Multidisciplinary Activities) for deferred maintenance projects.

The current NSF award for the operation of NHMFL spans CY 2023-2027. O&M support is provided by DMR and CHE with DMR's contribution escalated approximately one percent annually and CHE providing a flat $2.10 million. Additional funding for deferred maintenance may be provided by MPS' Office of Strategic Initiatives.

Reviews and Reports

NSF monitors annual plans and reports, including user metrics, and holds regular monthly teleconferences with the NHMFL director along with numerous *ad hoc* communications. NSF conducts annual external site-visit reviews to assess operations, maintenance, and new facility development as well as the user programs, in-house research, and long-term plans to contribute significantly to science and technology development both nationally and internationally. Annual reviews also assess the status of education, training and outreach, and diversity initiatives. Recommendations from annual reviews are used to inform NHMFL's operations planning and NSF's oversight thereof. Recent reviews include a hybrid site visit with program directors from different directorates and divisions at NSF and the Department of Energy in November 2022.

Renewal/Recompetition/Disposition

The current award for the operation of NHMFL started on January 1, 2023, and will end on December 31, 2027. Currently, there are no plans for disposition of this facility.

OCEAN OBSERVATORIES INITIATIVE (OOI)
https://oceanobservatories.org

Ocean Observatories Initiative Funding

(Dollars in Millions)

	FY 2023		Change over	
FY 2022	Estimate	FY 2024	FY 2023 Estimate Base	
Actual	Base	Request	Amount	Percent
$45.13	$51.00	$53.36	$2.36	4.6%

Brief Description

The Ocean Observatories Initiative is a networked observatory of *in situ* instrumentation delivering long-term, time-series data for multidisciplinary oceanographic research. It is composed of five arrays of instrumented platforms:

- Two Global Arrays of autonomous surface and sub-surface moorings deployed at deep water, high-latitude locations: (1) Station Papa Array in the Gulf of Alaska (Pacific Ocean), and (2) Irminger Sea Array off Greenland (Atlantic Ocean).
- One Regional Cabled Array (RCA) in the ocean basin off the coast of Oregon and Washington. RCA consists of a cabled network of interconnected sites and sensors on the seafloor spanning multiple geologic and oceanographic features and processes.
- Two Coastal Arrays composed of autonomous surface and sub-surface moorings, profilers, and gliders at shelf locations of the west and east coast of the U.S.: (1) Endurance Array off the coast of Washington and Oregon, and (2) Pioneer Array, a relocatable array off the U.S. East coast.

Real time and archived data from OOI's instruments are processed, stored, displayed, and served by the OOI cyberinfrastructure and are openly available to the public via the OOI website.

Meeting Scientific Community Needs

OOI provides the scientific community with continuous, interactive access to the interior of the ocean through an integrated network of arrays, many located in regions that are challenging to access via ship-board sampling. Deployed in critical parts of the global and U.S. coastal ocean, data from OOI instrumentation enable the study of complex, interlinked physical, chemical, biological and geological processes that occur on both short-term, episodic and long-term climate-related time scales.

OOI is a community resource providing researchers, the public, educators, and students with: (1) long-term time series data sets; (2) *in situ* ocean laboratory capabilities that allow users to develop and apply new technologies by connecting their instruments to OOI network; and (3) tools that support undergraduate classroom applications of OOI observations, as well as public outreach through informal education.

The overarching scientific themes of OOI, developed in close collaboration with and in response to, the needs of the science community, are outlined in the OOI Science Plan.[1] They span six multi-

[1] https://doi.org/10.23860/ooi-science-plan-2021-01

disciplinary domains, each with a multitude of research questions.

- *Ocean-Atmosphere Exchange*.
- *Climate Variability, Ocean Circulation, and Ecosystems*
- *Turbulent Mixing and Biophysical Interactions*
- *Coastal Ocean Dynamics and Ecosystems*
- *Fluid-Rock Interactions and the Subseafloor Biosphere*
- *Plate-Scale, Ocean Geodynamics*

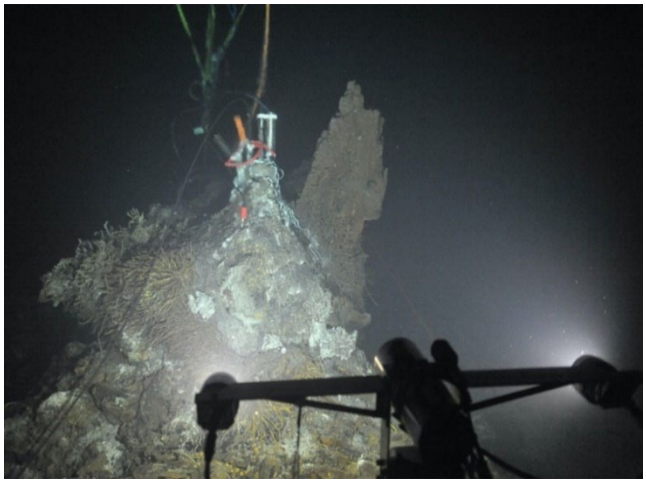
In October 2020, OOI launched a new data discovery tool, Data Explorer. The design of this tool was based on input from the science community and allows users to explore, use, and visualize OOI data in new ways that help advance understanding of the ocean, its processes, and how they are changing.

In 2021, a community consultation process informed the new location of the Pioneer Array, described further below. The OOI team continues to engage with its scientific users at major conferences through town halls, one-on-one engagement, and presentations.

Status of the Facility

OOI began full operations in FY 2016. Maintenance cruises are conducted once a year at each Global Array and the RCA, and twice a year at each Coastal Array. During these cruises, all instruments on both the RCA and mooring lines are replaced with refurbished and re-calibrated ones. At the same time, glider vehicles are replaced with newly serviced ones.

During operations, a subsample of the data collected on the instruments at the Global and Coastal Arrays is transmitted ashore in near-real time via satellite. All data are stored onboard the in-water instrument packages until retrieved during maintenance cruises. The subsampling interval depends on the parameter measured as well as on the bandwidth and power available for transmission. All data collected by the RCA, including video imagery and acoustic data, are transmitted ashore in real-time via the underwater fiber-optic cable.



The RCA cabled digital still camera, redeployed in 2015 by the Canadian ROV ROPOS, lights up the active hydrothermal vent called El Gordo in the international District Hydrothermal Field, located at the summit of Axial Seamount nearly a mile beneath the ocean surface. *Credit: UW/NSF-OOI/CSSF*.

The OOI cyberinfrastructure supports data handling, processing, and serving through the legacy Data Portal and the more recently developed Data Explorer. The latter was the outcome of user community feedback regarding data accessibility and discoverability, provided to the facility through the OOI Facility Board (OOIFB, described below under External Governance) and its Data Systems Committee (DSC). User satisfaction surveys from 2022 showed that the introduction of the Data Explorer increased user satisfaction when compared to the survey from 2019 when only the Data Portal was available.

The Data Explorer allows the user to: search for and download data of 200 different ocean parameters, from approximately 80 platforms and 800 instruments; compare datasets across regions and disciplines; and generate and share custom data views. It also allows the download of full datasets using NOAA's Environmental Research Division's Data Access Program. OOI serves data from each of OOI's five active arrays plus archived data from prior deployments. Users can search for data by parameter, location, and/or instrument type.

While most OOI Arrays are associated with a particular region or sampling site, the Pioneer Array was designed to be relocated every five years to a new region of scientific interest. Since 2013, the array had been located south of Martha's Vineyard on the New England shelf. NSF, in collaboration with the science community, initiated the process for its relocation to a new site. Through a series of Innovation Labs and with community input, NSF decided the Pioneer Array should be relocated to the Mid-Atlantic Bight, north of Cape Hatteras, North Carolina. In November 2022, the array was fully recovered from its New England location after nine years of continuous data collection. The Pioneer Array infrastructure and instrumentation packages are under refurbishment and in preparation for deployment in the new location in 2024.

Coastal Endurance Surface Buoy with sea lions.
Credit: Coastal Endurance Arrav Team. OSU.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is provided by a program officer in the GEO Division of Ocean Sciences (OCE), who works cooperatively with staff from Office of Budget, Finance, and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. The GEO facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

The Woods Hole Oceanographic Institution (WHOI) is the primary awardee and managing organization for OOI, responsible for overall operations, management, and maintenance. WHOI provides sub-awards to Oregon State University (OSU) and University of Washington (UW), and all three institutions comprise the OOI Implementing Organizations with the following responsibilities:

- WHOI – Overall OOI facility operation and maintenance, Global Stations, and Pioneer Array
- OSU – Endurance Array and the OOI Cyberinfrastructure Data Systems Center
- UW – RCA

The OOIFB, established in FY 2017, comprises members of the oceanography community, and provides independent input and guidance to NSF regarding the O&M of OOI. The DSC of the OOIFB evaluates and recommends improvements to data services policies and practices.

Partnerships and Other Funding Sources

OOI O&M is supported exclusively by NSF. Additional funding from NSF or other U.S. agencies is provided to individual researchers to cover costs associated with specific project expenses.

Funding

Total Obligations for OOI

(Dollars in Millions)

		FY 2023		**ESTIMATES**[1]				
	FY 2022	Estimate	FY 2024					
	Actual	Base	Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$45.13	$51.00	$53.36	$53.36	$53.36	$53.36	$53.36	$53.36

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends in September 2023.

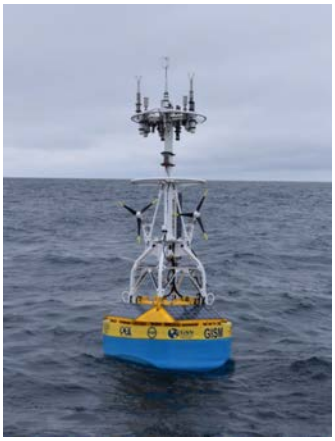
The FY 2024 Request includes $53.36 million for OOI. The increase above FY 2023 is associated with the recapitalization of the primary in-water infrastructure, upgrades to data-serving operations and cybersecurity, and addressing inflationary increases in equipment replacement, supplies, and other operational costs.

Reviews and Reports

All Global and Coastal Arrays utilize gliders to collect physical and biogeochemical data to supplement those collected by the stationary moorings. At the Global Arrays, the gliders collect data from the subsurface moorings using acoustic technics and relay the data to shore via satellite. *Credit: Sawyer Newman, WHOI.*

A mid-award review was conducted in November 2020 and covered all aspects of the OOI program. The outcome of the review was positive, and the panel recommended that the cooperative agreement with WHOI be renewed under the existing administrative and operational structure.

NSF completed a Business Systems Review (BSR) of WHOI's administrative business systems in October 2021, which determined that the administrative business systems supporting OOI are in alignment with federal regulations and meet compliance requirements. The report noted some areas that could be further strengthened to better meet NSF's expectations. Following the development and approval of an Implementation Plan, NSF closed the BSR in November 2022.



Global Irminger Array surface mooring that consists of a large surface buoy with meteorological instrumentation, satellite telemetry, wind turbines and solar panels to generate power, and instrumentation in the water to 1500 m depth. *Credit: OOI/WHOI.*

Renewal/Recompetition/Disposition

NSF completed the process of recompeting the O&M award through an open, merit-based external peer-review process, resulting in an award to WHOI as the OOI Program Management Office, that started October 1, 2018, and runs through September 30, 2023. NSF is engaged in a process to continue support for the facility beyond the current award period. Currently, there are no plans for disposition of the facility.

SEISMOLOGICAL FACILITY FOR THE ADVANCEMENT OF GEOSCIENCE (SAGE)
www.earthscope.org/about/gage-sage-facilities/

Seismological Facility for the Advancement of Geoscience Funding
(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$21.87	$23.37	$24.40	$1.03	4.4%

Brief Description

The Seismological Facility for the Advancement of Geoscience is a distributed, multi-user facility that enables a diverse principal investigator community to make advances in understanding Earth processes that would otherwise not be possible. SAGE provides the research community with access to seismic instrumentation, field training and support, and data services. The facility operates a global network of seismic stations; provides field and technical resources; supports data archiving, quality control, and distribution; and provides education and outreach activities that serve a wide range of audiences. SAGE deploys geophysical instruments globally onland, in polar regions, and under the oceans.

Meeting Scientific Community Needs

The Earth's interior remains a major scientific frontier holding the key to understanding the origin of the planet. Recent developments in seismic sensor design and the acquisition, transmission, and storage of data have resulted in dramatic improvements in the resolving power of seismic imaging of the Earth’s interior. To serve the research needs of the broad Earth science community, SAGE is organized under three primary service areas: Instrumentation Services, Data Services, and Education and Public Outreach.

Users include researchers who utilize SAGE instruments and/or data; educators who draw on SAGE teaching materials and training; other Federal agencies and international groups that employ SAGE resources and/or data for multiple operational purposes; and interested members of the public and private sector.

SAGE provides open access data and educational products at no cost to users. Scientists utilizing equipment, training, and other resources provided by SAGE typically are funded by awards from NSF, the U.S. Geological Survey (USGS), and other agencies. NSF-sponsored users are usually supported by the Division of Earth Sciences (EAR), the Division of Ocean Sciences(OCE), and OPP.

Demand remains high for data, equipment, and other resources provided by SAGE. In FY 2022:
- The total amount of data downloaded from the SAGE Data Management Center was the highest ever, with an increase of three percent over FY 2021;
- At least 91 field experiments used equipment and support provided by SAGE worldwide; and
- More than 300,000 classroom activities were downloaded by K-16 educational projects.

Status of the Facility

SAGE is currently in year five of a seven-year award, and the capabilities provided by the facility have evolved based on input from a series of community engagement activities, including an NSF-sponsored workshop entitled "Future Seismic and Geodetic Facility Needs in the Geosciences" held in 2015.[1] EAR continues to evaluate NSF's geophysical facilities to best enable emerging research directions. In 2018, EAR commissioned a National Academies of Sciences, Engineering, and Medicine decadal survey that identified top research priorities for the Earth sciences for the next decade. Released in July 2020, *A Vision for NSF Earth Sciences 2020-2030: Earth in Time*[2] reaffirmed the importance of NSF's seismic and geodetic facilities in advancing Earth science research over the next decade.

As part of the decadal survey process, a workshop entitled *Management Models for Future Seismological and Geodetic Facilities and Capabilities* was held to review the strengths and weaknesses of different management models for NSF geophysical facilities.[3] Following the release of the workshop report, EAR announced that, at the time of the next competition for their management and operations, the current SAGE and Geodetic Facility for the Advancement of GEoscience (GAGE) facilities would be consolidated into a single facility with a single operator.[4]

In FY 2020, GEO commissioned a portfolio review from a subcommittee of its Advisory Committee to inform planning for the future, consolidated geophysical facility. The portfolio review is also an important input to an ongoing effort to plan seismic research and related infrastructure in the U.S. over the next decade, so that NSF's geophysical facility will address the science priorities highlighted in the decadal survey. Additionally, the portfolio review report, which was completed in FY 2021, emphasized the importance of developing partnerships in support of elements of SAGE and GAGE that are mission critical for other Federal agencies. EAR is working to define the best path forward for a future facility and undertaking efforts to expand existing federal partnerships.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is provided by EAR, working cooperatively with OPP, the Office of the General Counsel, the Office of Legislative and Public Affairs, and the Office of Budget, Finance, and Award Management (BFA). Within BFA, the Large Facilities Office advises program staff and assists with agency oversight. The GEO facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

The SAGE facility awardee is a 501(c)(3) nonprofit corporation governed by a Board of Directors elected by institutional representatives. As of January 1, 2023, the Incorporated Research Institutions for Seismology (IRIS), Inc., which managed SAGE since the start of the current award in FY 2018, and UNAVCO (the managing entity for GAGE since the start of the current GAGE award in FY 2018) merged

[1] www.iris.edu/hq/files/workshops/2015/05/fusg/reports/futures_report_high.pdf

[2] www.nap.edu/catalog/25761/a-vision-for-nsf-earth-sciences-2020-2030-earth-in

[3] www.nap.edu/catalog/25536/management-models-for-future-seismological-and-geodetic-facilities-and-capabilities

[4] www.nsf.gov/pubs/2020/nsf20037/nsf20037.jsp

to form the EarthScope Consortium, Inc., with over 170 institutional members. This consortium now manages both GAGE and SAGE as discrete major facilities. Board members vet program decisions associated with SAGE management and operation through consultation with EarthScope Consortium staff and SAGE advisory committees.

Partnerships and Other Funding Sources

The GAGE facility is primarily supported by EAR. SAGE is heavily involved in partnership activities, many of which are international in nature. Installation and operations of the Global Seismographic Network (GSN) have resulted in contacts between scientists and government and non-government organizations around the world. Many international GSN stations are designated as the official stations for nuclear test ban treaty monitoring in their host countries. The USGS supports operation of two-thirds of the GSN.

Funding

Total Obligations for SAGE

(Dollars in Millions)

		FY 2023						
	FY 2022	Estimate	FY 2024	**ESTIMATES[1]**				
	Actual	Base	Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$21.87	$23.37	$24.40	$24.75	$24.75	$24.75	$24.75	$24.75

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends in September 2025. In 2020, NSF announced preparation for a competition for a future single, unified geophysical facility as the successor to SAGE and GAGE.

NSF is currently implementing recommendations from the community and prior reviews that include innovating SAGE's portable sensor pool to provide additional nodal instruments for studies of processes in Earth's near surface, moving data services for the facility to the cloud and recapitalizing aging instrumentation. A pilot cloud service program was initiated in 2020 in partnership with GAGE and the program plans to expand this capability over the remainder of the existing award period. The program is also implementing different strategies to address aging instrumentation, and plans to continue to phase in recapitalization over the current award period.

Reviews and Reports

NSF externally reviews components of the SAGE facility on an annual basis. In 2022, NSF conducted a review of the SAGE Education and Community Engagement activity, which was described by the review panel as "unparalleled and impactful" and having "an outsize[d] influence on Earth-sciences culture" in partnership with GAGE. NSF conducted a full management review of SAGE in September 2021, and the panel commended IRIS for its strong overall performance in operating and maintaining SAGE. NSF will conduct a follow-up review of the full facility in 2023.

Renewal/Recompetition/Disposition

In 2020, NSF announced preparation for a competition for a future single, unified geophysical facility as the successor to GAGE and SAGE. NSF plans to evolve components of GAGE and SAGE through the competition for the future facility to enable advances in the scientific priorities established by the *Earth in Time* decadal survey. NSF is considering the recommendations in the FY 2021 portfolio review, as

well as the interagency context, to formulate a strategy for continued support of this important community research resource. Disposition is not being considered at this time.

While the SAGE award was initially planned to end in 2023, NSF announced in June 2021 that it would extend the current awards for operations of both SAGE and GAGE to ensure continuity of services until 2025. This extension will allow NSF to work with agency partners to thoughtfully respond to the recommendations in the portfolio review.

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS (FFRDCS)

GREEN BANK OBSERVATORY (GBO)

www.greenbankobservatory.org

Green Bank Observatory Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$15.53	$10.83	$9.55	-$1.28	-11.8%

Brief Description

GBO is a major NSF research facility and FFRDC located in Green Bank, West Virginia. It is operated by Associated Universities, Inc. (AUI) under a cooperative agreement with NSF. GBO enables leading ground-based research at radio wavelengths by offering access to telescopes, facilities, and advanced instrumentation to the U.S. scientific community, and it conducts an active program of education and public outreach. GBO is also the administrative site of the 13,000-square-mile National Radio Quiet Zone, where radio transmissions are restricted by law. Having telescopes within this quiet zone allows detection of faint astronomical signals that would otherwise be overwhelmed by anthropogenic radio signals.

Meeting Scientific Community Needs

The main scientific instrument at GBO is the 100-meter Robert C. Byrd Green Bank Telescope (GBT), which is the world's largest fully steerable single-dish radio telescope, operating at frequencies from 0.2 GHz to 116 GHz. Its large sky coverage, very high sensitivity, and extensive suite of instruments make it a powerful and versatile telescope that continues to enable important advances in virtually all areas of modern astrophysics, including solar system and planetary astronomy; star formation and evolution; interstellar physics and chemistry; pulsar studies of long-wavelength gravitational waves; physics of black holes, neutron stars, and other compact objects; and galaxy formation and evolution. The GBT is complementary to and synergistic with interferometric arrays that are part of the National Radio Astronomy Observatory. It also plays a critical supporting role as a highly sensitive element of very long baseline interferometry as well as a bistatic radar receiver for rapid and sensitive imaging of near-Earth objects and asteroids. The GBT's focal plane is ideal for rapid, wide-field imaging using multi-pixel cameras.

Approximately 500 scientists use the GBT each year for research that spans virtually every field of modern astrophysics. Graduate students using the GBT gain vital hands-on experience with a major telescope, an increasingly rare opportunity but critical for their training. Further, there are opportunities for university groups to build and install new instruments (e.g., receivers and backends) on GBT, as well as prototype telescopes on the GBO site.

GBO also conducts a variety of education and public outreach programs and activities that have impact regionally and across North America. The Green Bank Science Center enables these programs and activities with its auditorium, classrooms, and large exhibit hall, visited by nearly 50,000 people every year. Thousands of K-12 teachers and students participate in educational programs using the

variety of radio telescopes available at GBO.

Status of the Facility

The GBT is currently used for observations approximately 6,500 hours per year. Of these, approximately 4,500 hours are available as Open Skies, or NSF-sponsored observing time, and are allocated through community-based peer review. The "oversubscription rate", or the ratio of the Open Skies time requested to the time granted, has been in the range of 2 to 3 since FY 2015. Non-open-skies time (about 2,000 hours) on the GBT is provided exclusively to GBO partners (see Partnerships section below) who make significant financial contributions to facility operations.

GBO conducts regular inspections of and maintenance on numerous components of its telescopes and site infrastructure. The last full structural inspection of the GBT by an independent engineering firm was completed in 2021. The report from that inspection identified key areas for future maintenance work and upgrades. Additional inspections are scheduled in 2024. Significant maintenance is underway including repairs to the track and foundation as well as replacement of damaged azimuth wheels of the GBT. A comprehensive plan to address major necessary maintenance due to the aging infrastructure of the GBT is also being developed.

The scientific direction and operations of the Observatory are assessed through regular NSF reviews, input from various community workshops, and AUI governance and external advisory committee meetings. Development and upgrade efforts are driven by community needs and priorities, address certain key recommendations of the NSF external merit review panel that evaluated the most recent renewal proposal, and align with strategic initiatives such as the NSF Windows on the Universe Big Idea. Thus, GBO is poised to address community needs and enable important advances in astronomy in the coming years.

Governance Structure and Partnerships

NSF Governance Structure

Oversight from NSF is led by a program officer in the Division of Astronomical Sciences (AST) who works cooperatively with staff from the Office of Budget, Finance and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice and assists with agency oversight and assurance. The MPS facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

GBO is managed and operated through a cooperative agreement with AUI, a non-profit research management organization consisting of an Executive office overseen by a Board of Trustees, with input from several internal and external committees. AUI manages GBO through its own community-based oversight and users committees. The GBO Director reports directly to the AUI Vice President for Radio Astronomy.

Partnerships and Other Funding Sources

External contributions represent approximately 30-35 percent of the total operations budget of GBO. These contributions come mostly from non-federal partners, including Breakthrough Listen (BL),[1] the

[1] www.breakthroughinitiatives.org/initiative/1

Gordon and Betty Moore Foundation,[2] and individual contracts for GBT observing time. The NSF-funded North American Nanohertz Observatory for Gravitational Waves (NANOGrav) Physics Frontiers Center also contributes to annual operations costs. Partnerships with BL and NANOGrav are anticipated to continue through FY 2024. Many of the GBO partnerships involve guaranteed allocations of observing time on the GBT in exchange for operations funding. Other partnership development efforts are continuing.

Funding

Total Obligations for GBO

(Dollars in Millions)

		FY 2023						
	FY 2022	Estimate	FY 2024	**ESTIMATES[1]**				
	Actual	Base	Request	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$9.12	$9.12	$9.12	$9.55	$9.55	$9.55	$9.55	$9.55
Special Projects[2,3]	6.41	1.71	0.43	-	-	-	-	-
TOTAL	**$15.53**	**$10.83**	**$9.55**	**$9.55**	**$9.55**	**$9.55**	**$9.55**	**$9.55**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends on September 30, 2024.

[2] Special projects reflects funding for repairs and maintenance beyond regular O&M.

[3] Funding in FY 2023 and FY 2024 does not include potential additional funding that may be provided by MPS' Office of Strategic Initiatives (formerly Office of Multidisciplinary Activities) for deferred maintenance projects.

The FY 2024 O&M request encompasses support for direct telescope operations at GBO, including maintenance, infrastructure upgrades, and telescope management, as well as funds allocated for education and public outreach. Additional funding for major maintenance identified as part of a midterm review of the GBT infrastructure is included under special projects. Additional funding for deferred maintenance may be provided by MPS' Office of Strategic Initiatives.

Reviews and Reports

In November 2021, the Decadal Survey of Astronomy and Astrophysics, "Pathways to Discovery (Astro2020),"[3] identified the need for three key capabilities to advance radio astronomy: long term timing of pulsars, development of new instrumentation, and mitigation of radio-frequency interference. The GBT is involved in each of these activities and is poised to play a key role in all three. The report recommended continuing operations of the GBT, particularly for pulsar-timing observations, as well as the development of radio cameras.

NSF conducts annual reviews of the program operating plan and reports, including external advice from community representatives. Recommendations from these reviews are used to inform GBO's operations planning and NSF's oversight.

Renewal/Recompetition/Disposition

NSF's current cooperative agreement with AUI for operations and management of GBO spans the five-year period October 1, 2019 – September 30, 2024. In accordance with standard procedures, NSF is assessing options regarding renewal, competition, or disposition of the facility beyond FY 2024 based

[2] www.moore.org/

[3] www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020

on the November 2022 comprehensive review, as well as key scientific, strategic, and administrative considerations.

Views showing the Green Bank Telescope in the Fall (left) as well as the unblocked aperture and fully steerable structure (right). *Credit: GBO/AUI.*

NATIONAL CENTER FOR ATMOSPHEIRC RESEARCH (NCAR)
https://ncar.ucar.edu/

National Center for Atmosperic Research Funding
(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$104.64	$116.20	$134.41	$18.21	15.7%

Brief Description

The National Center for Atmospheric Research is an NSF-sponsored Federally Funded Research and Development Center guided by the vision: "a world-class research center leading, promoting and facilitating innovation in the atmospheric and related Earth Systems sciences." NCAR's expert staff of research scientists, engineers, education and outreach specialists, and support personnel collaborates closely with colleagues in the academic community to improve understanding and prediction of the sun-Earth system, including the human dimensions. This work is crucial to improving the Nation's ability to navigate the challenges presented by our rapidly changing climate.

NCAR's primary locations are the Mesa Laboratory in Boulder, Colorado (CO), the Research Aviation Facility (RAF) in nearby Broomfield, CO, the NCAR-Wyoming (WY) Supercomputing Center (NWSC) in Cheyenne, WY, and the Mauna Loa Solar Observatory in Hawaii (HI).

Meeting Scientific Community Needs

NCAR's mission is to understand the behavior of the atmosphere and related Earth and geospace systems; to support, enhance, and extend the capabilities of the university and broader scientific communities, nationally and internationally; and to foster the transfer of knowledge and technology for the betterment of life on Earth. NCAR fulfills this mission with highly integrated research and facilities organized around three overlapping primary areas of activity: cutting edge airborne and ground-based observational facilities; community weather and climate models with many thousands of users worldwide; and petascale high-performance computing. Cross-cutting programs promote education, career development, public engagement, and increased diversity for the entire geosciences community. NCAR maintains an extensive range of partnerships throughout the academic, private, and government sectors.

NCAR's programs are guided by the 2020 – 2024 NCAR Strategic Plan, which was developed with broad community input and emphasizes three overlapping priorities: 1) enhancing and building on NCAR's core strengths in fundamental research in the atmospheric and related sciences; 2) promoting integrated Earth System Science; and 3) advancing actionable science, to help address society's most pressing environmental challenges.

Status of the Facility

NCAR is operated for NSF by the University Corporation for Atmospheric Research (UCAR), a

consortium of 122 member universities in the U.S. and overseas. Several significant infrastructure improvement projects have recently been completed, including a full overhaul of the primary heating and cooling systems at the Mesa Laboratory that will result in considerable increases in efficiency and reduced operating costs. A major renovation of the RAF at the Rocky Mountain Metropolitan Airport has provided new, state-of-the art laboratory, engineering, and technical space in support of the two NSF-owned, NCAR-operated research aircraft and the community of scientists and engineers that use them. The propellers on the NCAR C-130 aircraft were recently upgraded to improve range and efficiency.

The completion of a major upgrade to the NWSC in 2023 will result in a more than threefold increase in the computing speeds available to users in the Earth System Science research community, together with enhanced capabilities for supporting applications in machine learning and artificial intelligence. The new system is called 'Derecho' following a statewide naming competition among Wyoming school students.

NCAR's Mauna Loa Solar Observatory, in HI, has been closed since November 2022, following a nearby volcanic eruption. NCAR is working with the National Oceanographic and Atmospheric Administration, the site's owner, on a schedule for resuming operations as conditions allow.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is provided by program officers in GEO's Division of Atmospheric and Geospace Sciences who work cooperatively with staff from other GEO divisions, the Office of Budget, Finance, and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. The GEO facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

UCAR engages NCAR's stakeholders in its governance, strategic planning, and program implementation through mechanisms such as a dedicated subcommittee of the UCAR Board of Trustees; standing external advisory committees for each NCAR laboratory, the NCAR Director and certain targeted initiatives; panels for allocating computing and observing resources; and governance bodies for the community models. Other sources of input include community workshops, *ad hoc* working groups, and studies by the National Academies of Sciences, Engineering, and Medicine.

Partnerships and Other Funding Sources

NCAR leverages its NSF funding with significant support from other sources. Other federal agencies typically provide approximately 25 percent of NCAR's total annual budget. A further 8-10 percent comes from state and local governments, universities, industry, and non-profits. This funding, which must directly support NCAR's NSF-funded program, extends NCAR's fundamental research into a wide variety of applications such as wildfire management, road and aviation safety, public health, and renewable power generation.

Funding

Total Obligations for NCAR

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Operations & Maintenance	$104.64	$116.20	$121.00	$121.00	$121.00	$121.00	$121.00	$121.00
Deferred Maintenance	-	-	13.41	-	-	-	-	-
TOTAL	**$104.64**	**$116.20**	**$134.41**	**$121.00**	**$121.00**	**$121.00**	**$121.00**	**$121.00**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends in September 2023.

NSF's FY 2024 Request for NCAR provides for recurring infrastructure costs including periodic technology refreshes of the NCAR supercomputers, scheduled aircraft maintenance, and upgrades to the NCAR buildings. Additional one-time NSF funding ($13.41 million) will be provided for projects that improve NCAR's ability to carry out its mission as well as increase the energy efficiency and resilience of the infrastructure, such as replacing deteriorating original building systems from the 1960s.

Reviews and Reports

NSF conducts a comprehensive review of NCAR's science programs, facilities, and management at the mid-point of each five-year award. The 2021 review comprised site visits by four teams of external experts assessing: (1) Observing Science and Facilities; (2) Computation and Data Science and Facilities; (3) Community Modeling and Data Assimilation and (4) Management. The first three visits occurred between May and June 2021, and the fourth was held in August 2021. Findings from the reviews have been incorporated into NCAR's program plans. A Business Systems Review was conducted in summer 2022.

Renewal/Recompetition/Disposition

The current five-year award to manage and operate NCAR was made to UCAR, beginning October 1, 2018. This award may be extended for an additional five-year term, subject to adequate awardee performance, NSF review of a renewal proposal and NSB authorization of an award. NSF's review of awardee performance took place in 2021, as described previously. Remaining steps in the process are currently underway.

NATIONAL RADIO ASTRONOMY OBSERVATORY (NRAO)
https://public.nrao.edu/

National Radio Astronomy Observatory Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$102.72	$93.66	$98.35	$4.69	5.0%

Brief Description

NRAO is a Federally Funded Research and Development Center that conceives, designs, builds, operates, and maintains radio telescopes used to study all types of astronomical objects, from bodies in our solar system to objects in the distant universe. Operating synergistically with optical, infrared, and x-ray telescopes, NRAO's state-of-the-art, general-purpose facilities enable discovery over a broad range of key questions in modern astrophysics. NRAO operates the North American component of the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile, the Karl G. Jansky Very Large Array (VLA) near Socorro, New Mexico, the Very Long Baseline Array (VLBA) throughout the continental United States, Hawaii, and the U.S. Virgin Islands, and the Central Development Laboratory (CDL) in Charlottesville, Virginia.

Meeting Scientific Community Needs

Since 1956, NRAO has provided world-class radio telescope facilities for use by the U.S. and international scientific community. NRAO also provides both formal and informal programs in education and public outreach for teachers, students, the public, and the media.

NRAO's observing facilities for radio astronomy are available to researchers, regardless of affiliation or nationality, based on merit-reviewed scientific proposals. NRAO facilities annually serve over 2,500 users worldwide; moreover, continued high demand for ALMA has resulted in the most proposals ever received (1,836) for an astronomical facility in response to a single proposal call. NRAO is among the top three astronomical facilities worldwide for the highest publication numbers (937 in 2022) and over 810,00 total citations.

NRAO facilities continue to enable ground-breaking discoveries, from the detection of a massive flare from our nearest stellar neighbor to the detection of unusually massive galaxies and black holes in the very early universe. Using data from VLA sky surveys twenty years apart, astronomers were able to detect jets of relativistic charged particles from near supermassive black holes that had been launched during that interval, providing insight into how these enigmatic phenomena are created. Closer to Earth, ALMA showed that volcanoes are responsible for the sulfur dioxide gas in the atmosphere of Jupiter's moon, Io.

The National Academies of Sciences, Engineering, and Medicine Decadal Survey for Astronomy and Astrophysics (Astro2020)[1] identified time-domain astronomy and multi-messenger astrophysics (MMA) as components of one of the three scientific pillars for the next decade. NRAO facilities support crucial radio observations of MMA events by providing timely follow-up observations of transients and archival data supporting longer-term studies of those events. Astro2020 also identifies the next-generation Very Large Array (ngVLA) as an important component of the portfolio of future ground- and space-based facilities needed to achieve the ambitious scientific goals of the report. NRAO is continuing to lead development efforts for the potential ngVLA.

Status of the Facility

Atacama Large Millimeter/submillimeter Array

ALMA is the world's preeminent facility for millimeter- and submillimeter-wave astronomy, enabling transformational research into the physics of the cold universe, regions that are optically dark but shine brightly in the millimeter/submillimeter portion of the electromagnetic spectrum. In late CY 2022, the Joint ALMA Operations center in Chile suffered a cyberattack that halted operations but did not result in any data loss. As of December 2022, operations have resumed with new policies, procedures, and reviews by international partners based on lessons learned. Additional security measures will be enacted pending further reviews.

Karl G. Jansky Very Large Array (VLA)

The VLA is one of the world's most sensitive and flexible instruments for centimeter-wavelength continuum and imaging spectroscopy. The VLA operates over a very large range of wavelengths (0.6 to 30 cm, plus narrow windows at 90 cm and 400 cm) using 27 separate 25-meter radio telescopes located in central New Mexico about 50 miles west of Socorro. The VLA is conducting an all-sky survey that will provide the astronomy community with archival data for many years to come and that will support multi-wavelength synoptic surveys using existing and future facilities, such as the Vera C. Rubin Observatory.

Very Long Baseline Array (VLBA)

The VLBA is the world's preeminent facility for high-precision astrometric studies and high-resolution imaging, comprising ten 25-meter diameter telescopes distributed across the U.S., from the U.S. Virgin Islands to Hawaii. The U.S. Naval Observatory (USNO) continues to rely on VLBA data for mission-critical measurements of Earth orientation, data necessary for accurate functioning of GPS and has recently provided funding to make the infrastructure more reliable.

Central Development Laboratory (CDL)

The CDL supports NRAO's existing facilities, and provides technology and expertise needed to build the next generation of radio astronomy instruments and facilities. Most recently the CDL has been supporting the development of powerful radar transmitters for the Green Bank Telescope, development of sensitive next-generation receivers for ALMA and potentially ngVLA, and an upgraded correlator for ALMA.

[1] www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is led by a program officer in the MPS Division of Astronomical Sciences (AST), who works cooperatively with staff in the Office of Budget, Finance and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice and assists with agency oversight and assurance. The MPS facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

NRAO is managed and operated through a cooperative agreement with Associated Universities Inc. (AUI), a non-profit research management organization consisting of an Executive office overseen by a Board of Trustees, with input from several internal and external committees. AUI manages the observatory through its own community-based oversight and users committees. The NRAO director reports to the AUI president. Oversight of the international ALMA project is vested in the ALMA Board. The AST Division Director and NRAO program officer participate in the international ALMA Board and attend governance and advisory committee meetings for NRAO and its managing organization, AUI. An international review committee advises the ALMA Board.

Partnerships and Other Funding Sources

NRAO supplements NSF/AST support with funding provided by other NSF sources, other federal agencies, and non-federal sources. The development of new telescopes, instrumentation, and sensor techniques is conducted in partnership with relevant industries through competitive sub-awards to various large and small aerospace companies, radio antenna manufacturing firms, and specialized electronics and computer hardware and software companies. USNO provides approximately 50 percent of the funding for the VLBA.

View of the Very Large Array. *Credit: NRAO/AUI/NSF.*

ALMA is supported by an international partnership, comprising the United States and its partners Canada and Taiwan ("North America" or NA), the European Southern Observatory (ESO), and Japan and its partners Taiwan and South Korea (East Asia (EA)). NA and ESO are equal (37.5 percent) partners and EA contributes 25 percent. Canada contributes approximately 2.72 percent of operations (i.e., 7.25 percent of the 37.5 percent NA share). Taiwan contributed about 4 percent of NA construction costs but contributes operations funding through the EA partnership.

Funding

Total Obligations for NRAO

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
NRAO[2]	$52.09	$43.03	$43.59	$44.37	$45.59	$45.59	$45.59	$45.59
Operations & Maintenance	*40.53*	*40.53*	*40.53*	*44.37*	*45.59*	*45.59*	*45.59*	*45.59*
Special Projects [3,4]	*11.56*	*2.50*	*3.06*	-	-	-	-	-
ALMA Operations	50.63	50.63	54.76	56.96	59.24	59.24	59.24	59.24
Operations & Maintenance	*50.63*	*50.63*	*50.63*	*56.96*	*59.24*	*59.24*	*59.24*	*59.24*
Special Projects [3,4]	-	-	*4.13*	-	-	-	-	-
TOTAL	**$102.72**	**$93.66**	**$98.35**	**$101.33**	**$104.83**	**$104.83**	**$104.83**	**$104.83**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends September 30, 2026.

[2] Operations funding for NSF's contribution to VLBA is included in the NRAO total at $3.43 million per year.

[3] Special Projects reflects funding for repairs and maintenance beyond regular O&M, as well as extraordinary inflationary impacts on O&M. NRAO Special Projects also includes funding for the ngVLA program office.

[4] Funding in FY 2023 and FY 2024 does not include potential additional funding that may be provided by MPS' Office of Strategic Initiatives (formerly Office of Multidisciplinary Activities) for deferred maintenance projects.

The FY 2024 Request funds NRAO and the U.S. share of ALMA O&M costs, including ongoing support for education and public outreach programs as well as development programs, such as planning for ngVLA. In FY 2022, funding was provided to NRAO in support of the ngVLA program office (covering efforts across both FY 2022 and FY 2023). The FY 2024 request also includes additional funding under special projects for maintenance and upgrade costs, including structural repairs of buildings in New Mexico, replacement of cryogenic cold head spares, and vehicle renewals. Continued funding for the ngVLA program office is under review and, if funded, will be added as a supplement. Additional funding for deferred maintenance may be provided by MPS' Office of Strategic Initiatives.

Reviews and Reports

NSF conducts annual reviews of the NRAO Program Operating Plan and strategic planning documents, ALMA operations, and the AUI Management Report. Recommendations from these annual reviews, by external panelists are routinely used to inform NRAO's operations planning and NSF's oversight of the facility. A comprehensive management review was conducted in December 2021 by an external panel of experts.

Renewal/Recompetition/Disposition

Following a solicitation issued in FY 2014, the O&M of NRAO, including VLA, North American contributions to ALMA, and associated development laboratories, administration, and management functions, was competed and the National Science Board (NSB) authorized a 10-year award to AUI for the period October 1, 2016 – September 30, 2026. NSF will assess the options regarding renewal, competition, or disposition of the facilities operated by NRAO beyond FY 2026, in accordance with NSF policy.

NATIONAL SOLAR OBSERVATORY (NSO)
https://nso.edu/

National Solar Observatory Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Percent
$26.54	$26.56	$27.67	$1.11	4.2%

Brief Description

As a Federally Funded Research and Development Center, NSO is NSF's central institution for support of ground-based solar astronomy in the United States. Headquartered on the campus of the University of Colorado, Boulder, NSO provides leadership to the global solar astronomy community through operations of the Daniel K. Inouye Solar Telescope (DKIST). DKIST is the largest and most advanced solar telescope on the planet, poised to answer fundamental questions in solar physics by providing transformative improvements over other ground-based facilities.

NSO also operates the NSO Integrated Synoptic Program (NISP), which consists of the Global Oscillations Network Group (GONG) facility and the Synoptic Long-term Investigations of the Sun (SOLIS) telescope. GONG is a coordinated worldwide network of six telescopes specifically designed to study solar oscillations and, more recently, to provide critical data products for the prediction of space weather. NSO routinely provides detailed synoptic solar data from NISP for use by individual researchers and other government agencies through the NSO Digital Library.

Meeting Scientific Community Needs

The mission of NSO is to advance our knowledge of the Sun, both as an astronomical object and as the dominant external influence on the Earth, by providing forefront observational capabilities to the scientific research community. NSO operates a suite of ground-based optical and infrared solar telescopes and auxiliary instrumentation, allowing solar physicists to probe all aspects of the Sun, from the deep solar interior to its interface with the interplanetary medium.

NSO's flagship telescope, DKIST, enables the study of magnetic phenomena in the solar photosphere, chromosphere, and corona. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity, including flares and coronal mass ejections and their impact on planets. Solar activity can affect life on Earth through phenomena generally described as space weather and may have impacts on the terrestrial climate.

Other NSO assets provide data to space weather researchers in their efforts to understand solar eruptions and their effect on the Earth, and to apply that knowledge to the protection of satellites, astronauts, land-based power systems, and Earth's climate. GONG is critical infrastructure for operational space weather prediction and provides data necessary for refinement of solar forecasting models.

Status of the Facility

Although delayed due to impacts of the COVID-19 pandemic, construction of DKIST at the summit of Haleakalā on Maui, Hawai'i was completed in November 2021. The DKIST operations commissioning phase (OCP) began in December of the same year. Shared-risk science observations from the first peer-reviewed proposal cycle were made through CY 2022, including coordinated observing campaigns with other observatories. The second call for observing proposals was issued in the summer of CY 2022 for observations from late CY 2022 into CY 2023. Throughout 2022, there was considerable time for the development, testing, and verification of instrument configurations and combinations on the telescope.

The DKIST Data Center is located in Boulder, Colorado at the NSO headquarters, where observational data will be curated and made publicly available after an initial proprietary period. NSO data, including GONG data, are made available to the user community via the Virtual Solar Observatory.

The importance of DKIST science has been reaffirmed by the National Academies of Sciences, Engineering, and Medicine in multiple decadal surveys for Astronomy[1] and for Solar and Space Physics[2]. The recently released 2020 Decadal Survey for Astronomy and Astrophysics, *Pathways to Discovery* (Astro2020)[3] noted the importance of both global observations of our Sun, such as those provided by NSO's GONG facility, and detailed observations, such as those enabled by DKIST, which, it stated, "will revolutionize observations of the Sun's atmosphere."

NSO has been in the process of transitioning away from its user facilities at Kitt Peak, Arizona and Sacramento Peak, New Mexico, which began operations in 1962 and 1969, respectively. Although both sites were once the best ground-based facilities available to the entire U.S. solar research community, there are currently better ground-based facilities both inside and outside the United States. NSO provides limited site infrastructure support at the Sunspot Solar Observatory (formerly Sacramento Peak Observatory) to New Mexico State University (NMSU), which is responsible for the science operations of the Dunn Solar Telescope. The McMath Pearce Solar Telescope on Kitt Peak was transitioned to NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab) as an astronomy outreach center. NISP's SOLIS telescope was removed from Kitt Peak National Observatory and is now co-located with one of NSO's GONG shelters on the grounds of Big Bear Solar Observatory, which is operated by New Jersey Institute of Technology with support from multiple agencies including NSF and the National Aeronautics and Space Administration (NASA). SOLIS has been installed in a new telescope enclosure and is in a commissioning phase. Operations and maintenance will continue to be supported by NSO.

Governance Structure and Partnerships

<u>NSF Governance Structure</u>
NSF oversight is led by a program officer in the MPS Division of Astronomical Sciences, who works cooperatively with staff from BFA, the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice and assists with agency oversight

[1] www.nap.edu/catalog/12951/new-worlds-new-horizons-in-astronomy-and-astrophysics

[2] www.nap.edu/catalog/13060/solar-and-space-physics-a-science-for-a-technological-society

[3] www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020

and assurance. The MPS facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

NSO is managed by the Association of Universities for Research in Astronomy Inc. (AURA), through a cooperative agreement with NSF. The NSO director reports to the president of AURA. AURA receives advice from its Solar Observatory Council, composed of scientific and management experts. The NSO director receives advice on all aspects of user experiences from a User Committee, composed of scientists with considerable experience with the observatory. The NSF program officer for NSO has frequent discussions with NSO management and carries out reviews of the facility, attends meetings of the Solar Observatory Council and the Users Committee as an *ex officio* observer, conducts periodic site visits, and attends community science meetings to stay current with the solar community.

Partnerships and Other Funding Sources

NSO's partners include the National Oceanic and Atmospheric Administration (NOAA), NASA, and industrial entities as well as academic institutions on solar instrumentation development. NOAA contributes approximately $1 million per year to GONG operations under an interagency agreement with NSF. NMSU operates the Dunn Solar Telescope at Sunspot Solar Observatory through a consortium of universities, while NSO continues to maintain the site infrastructure. NSO has partnered with Big Bear Solar Observatory to operate the SOLIS facility.

Funding

Total Obligations for NSO

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
NSO	$6.96	$5.88	$6.24	$5.88	$5.88	$5.88	$5.88	$5.88
Operations & Maintenance	*5.88*	*5.88*	*5.88*	*5.88*	*5.88*	*5.88*	*5.88*	*5.88*
Special Projects [2,3]	*1.08*	-	*0.36*	-	-	-	-	-
DKIST Operations	19.58	20.68	21.43	21.43	21.43	21.43	21.43	21.43
Operations & Maintenance	*19.58*	*19.58*	*19.58*	*21.43*	*21.43*	*21.43*	*21.43*	*21.43*
Special Projects [3,4]	-	*1.10*	*1.85*	-	-	-	-	-
TOTAL	**$26.54**	**$26.56**	**$27.67**	**$27.31**	**$27.31**	**$27.31**	**$27.31**	**$27.31**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends in September 30, 2024.

[2] NSO Special Projects reflects transition activities at Scramento Peak Observatory.

[3] Funding in FY 2023 and FY 2024 does not include potential additional funding that may be provided by MPS' Office of Strategic Initiatives (formerly Office of Multidisciplinary Activities) for deferred maintenance projects.

[4] DKIST Special Projects reflects additional funding for research infrastructure to optimize community access.

The budget request for FY 2024 funds base NSO operations, including NISP, as well DKIST operations. Base NSO operations do not include the costs associated with the transition of former NSO facilities on Sacramento Peak and Kitt Peak. Total funding for DKIST increases in FY 2024 as the new telescope continues to transition into full operations. In FY 2022, a supplement for $1.08 million was made to NSO for Sacramento Peak, which included a subaward to NMSU for science observing. Funding for

transitioning Sacramento Peak infrastructure is included under special projects in FY 2024. Additional funding for deferred maintenance may be provided by MPS' Office of Strategic Initiatives.

Reviews and Reports

In July 2019, a comprehensive review of NSO's midterm progress report and long-range plan for the second five years of the cooperative agreement was conducted. The results of this review were presented to the National Science Board (NSB) in February 2020. NSF conducts regular reviews of NSO's Annual Progress Report and Program Plan (APRPP). A review of the FY 2021-FY 2022 APRPP was held onsite at NSO headquarters on June 1-3, 2022. The FY 2022 – FY 2023 APRPP review will be held in FY2023 Q3.

Renewal/Recompetition/Disposition

The NSB approved the renewal of the NSO/DKIST cooperative agreement in August 2014; the award began June 1, 2015, and will run through September 30, 2024. NSF is assessing the options regarding renewal, competition, or disposition of the facilities operated by NSO beyond FY 2024, in accordance with NSF policy. The NSF-NSO-NMSU partnership has resulted in partial operation of the Dunn Solar Telescope and the Visitor Center at NSO's Sacramento Peak Observatory in Sunspot, New Mexico as part of the divestment of operations costs of that facility. This partnership is being evaluated in coordination with the assessment of the options for NSO beyond FY 2024.

NSF'S NATIONAL OPTICAL-INFRARED ASTRONOMY RESEARCH LABORATORY (NSF'S NOIRLAB)
https://noirlab.edu/public/

NSF's National Optical-Infrared Astronomy Research Laboratory Funding

(Dollars in Millions)

	FY 2023		Change over	
FY 2022	Estimate	FY 2024	FY 2023 Estimate Base	
Actual	Base	Request	Amount	Percent
$56.38	$73.57	$82.21	$8.64	11.7%

Brief Description

Launched on October 1, 2019, NSF's NOIRLab integrates into a single center Vera C. Rubin Observatory operation (excluding the Rubin Observatory construction project), the International Gemini Observatory, and the programs and activities that were previously associated with NSF's National Optical Astronomy Observatory (NOAO). NOIRLab is managed for NSF by the Association of Universities for Research in Astronomy, Inc. (AURA). NOIRLab operates the Kitt Peak National Observatory (KPNO) and the Cerro Tololo Inter-American Observatory (CTIO), now collectively known as the Mid-Scale Observatories (MSO), as well as the Community Science and Data Center (CSDC) in Tucson, Arizona. As a Federally Funded Research and Development Center (FFRDC), NOIRLab coordinates the observational, technical, and data-management capabilities across all these facilities. NOIRLab also develops and sustains domestic and international partnerships with a view to advancing observational astronomy for the entire U.S. community. NOIRLab is a strategic priority for the MPS Division of Astronomical Sciences (AST) to facilitate U.S. leadership in optical-infrared (OIR) astronomy. NOIRLab promotes efficient operations across its observatories and centers and provides a cornerstone for NSF investment in the next generation of OIR facilities.

Meeting Scientific Community Needs

NOIRLab is the hub of U.S. ground-based OIR astronomy in the era of Rubin Observatory, time domain astronomy (TDA), multi-messenger astrophysics (MMA), and data-intensive science. NOIRLab is central to NSF's implementation of recommendations from the Astro2020 decadal survey.[1] By providing public access to a diverse portfolio of telescopes and instruments, NOIRLab enables pursuit of a broad range of modern astrophysical challenges, from studying small bodies in the solar system to characterizing the most distant galaxies and indirectly observing dark matter and dark energy.

NOIRLab's facilities are open to all astronomers regardless of institutional affiliation, with services provided to approximately 1,200 graduate and undergraduate students annually. Each year, NOIRLab telescopes feature in over 700 peer-reviewed scientific papers.

Recognizing an increased need for the characterization and study of transient events found by Rubin Observatory and MMA alerts from NSF's LIGO and IceCube facilities, NOIRLab has developed the Arizona–NOIRLab Temporal Analysis and Response to Events System (ANTARES), a software tool

[1] www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020

designed to rapidly process information from many thousands of changing objects. In addition, NOIRLab has set up the Astronomical Event Observatory Network (AEON) for immediate follow-up observations once interesting objects are identified. Through NSF supplemental support, NOIRLab is also constructing a new, state-of-the-art, adaptive optics system for Gemini-North (located atop Maunakea, Hawaii) and is re-commissioning instruments on the Victor M. Blanco and the Southern Astrophysical Research (SOAR) telescopes (both part of the CTIO, located in the Chilean Andes) specifically for TDA and MMA follow-up. NOIRLab is also taking a lead role in studies of planets around other stars, through the NASA-NSF Exoplanet Exploration (NN-Explore) program at the WIYN telescope (at KPNO) and by pursuing continued improvements in Extreme-Precision Radial Velocity instrumentation on NOIRLab's Gemini telescope.

Status of the Facility

NOIRLab operates facilities at four mountaintop sites in Arizona, Hawaii, and Chile. The International Gemini Observatory comprises two 8-meter telescopes: Gemini-North on Maunakea in Hawaii and Gemini-South on Cerro Pachón in northern Chile. The MSO supports two 4-meter class telescopes at KPNO in Arizona, WIYN and Mayall, as well as two 4-meter class telescopes at CTIO in Chile, SOAR and Blanco. Operations after the COVID-19 pandemic have returned to normal at these facilities, with remote observing possible at many NOIRLab telescopes. Rubin Observatory, located on the same summit as Gemini-South, is in pre-operations as it prepares to begin its ambitious 10-year imaging survey (see the Vera C. Rubin Observatory narrative in the MREFC section of Research Infrastructure).

On June 11, 2022, the Contreras wildfire was ignited by a lightning strike on Tohono O'odham Nation land south of KPNO. The fire passed through KPNO the weekend of June 17-19, destroying three small storage buildings (two of which were owned by the University of Arizona), and damaging two NOIRLab dormitories. Due to the heroic efforts of local firefighters and KPNO staff, none of the telescopes or instruments were damaged. However, facilities were impacted by smoke and ash, and guard-rails along the summit access road were destroyed, as were power and internet poles and cables. Operations slowly resumed after a 3-month period of clean-up and repairs to utilities and have now returned to normal.

On October 20, 2022, the 8.1-meter primary mirror of the Gemini-North telescope suffered damage to two areas just outside its light-collecting area while being moved for stripping prior to recoating. Detailed inspections found no evidence of damage elsewhere on the mirror. The telescope has since been unavailable for use while repairs are effected. Operations are anticipated to resume in March 2023.

After COVID-related delays, two major new instruments at Kitt Peak, the extreme precision radial velocity spectrometer for exoplanet research (NEID), operated in collaboration with NASA, and the 5000-fiber Dark Energy Survey Instrument (DESI), a DOE project, were successfully commissioned on the WIYN and Mayall telescopes, respectively. Both began their surveys in mid-2021. DESI has already completed over 20 percent of its survey, obtaining spectroscopic redshift for over 10 million galaxies to-date. The new Gemini facility instrument GHOST has, in the meantime, been safely delivered to Gemini-South and is being commissioned in 2023.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight is led by four program officers in MPS AST who work cooperatively on an Integrated Program Team (IPT) with staff from the Office of Budget, Finance, and Award Management (BFA), the Office of the General Counsel, the Office of Legislative and Public Affairs and other NSF offices as needed. The team makes use of quarterly and annual programmatic and financial reporting as well as pre-defined key performance indicators to measure performance; these are defined in a Performance Evaluation and Measurement Plan that is updated annually. Within BFA, the Large Facilities Office provides advice and assists with agency oversight and assurance. The MPS facilities team and the Chief Officer for Research Facilities also provide high-level guidance, support, and oversight.

External Governance Structure

AURA and the NOIRLab Director receive advice from AURA's NOIRLab Management Oversight Council. MSO and Gemini have Users' Committees, which advise on science operations. For Rubin, a management board with members from AURA, the lead DOE lab, and the SLAC National Accelerator Laboratory, approves new observing modes and capabilities. Gemini is governed by the Gemini Board, guided by the International Gemini Agreement. The board acts as the primary forum for interactions and decisions among partners and is the body with overall budgetary and policy control for Gemini.

Partnerships and Other Funding Sources

NOIRLab and its component programs support several partnerships on behalf of NSF. The Gemini partnership includes agencies from Canada, Brazil, Argentina, Chile, and the Republic of Korea. Along with NSF, all are signatories to the International Gemini Agreement. The SOAR telescope is supported by Brazil, NOIRLab, the University of North Carolina Chapel Hill, and Michigan State University; WIYN is supported by the University of Wisconsin, Indiana University, and NOIRLab, with other institutions, including NASA, as operational partners. NSF and DOE jointly support Rubin Observatory, as well as major instrumentation and surveys at the Blanco and Mayall telescopes. Many U.S. universities, meanwhile, operate their own telescopes at KPNO and CTIO, with reimbursed services provided by NOIRLab.

Funding

Total Obligations for NOIRLab

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	ESTIMATES[1] FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Vera C. Rubin Observatory Operations	$5.20	$22.10	$33.80	$38.45	$38.25	$38.22	$38.63	$39.88
Gemini Observatory	25.38	22.98	24.73	25.49	26.26	27.04	27.04	27.04
Operations and Maintenance	*23.32*	*22.98*	*22.98*	*25.49*	*26.26*	*27.04*	*27.04*	*27.04*
Special Projects [2,3]	*2.06*	-	*1.75*	-	-	-	-	-
Mid-Scale Observatories & CSDC	25.80	28.49	23.68	24.59	25.33	25.73	25.73	25.73
Operations and Maintenance	*21.13*	*21.13*	*22.40*	*23.27*	*23.98*	*24.33*	*25.73*	*25.73*
Special Projects [3,4]	*4.67*	*7.36*	*1.28*	*1.32*	*1.35*	*1.40*	-	-
TOTAL[5]	**$56.38**	**$73.57**	**$82.21**	**$88.53**	**$89.84**	**$90.99**	**$91.40**	**$92.65**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends September 30, 2027.

[2] Gemini Special Projects includes additional funding of $2.06 in FY 2022 for a new photovoltaic power system for Gemini-South. The FY 2024 Request includes $1.75 million for repairs and maintenance beyond regular O&M.

[3] Funding in FY 2023 and FY 2024 does not include potential additional funding that may be provided by MPS' Office of Strategic Initiatives (formerly Office of Multidisciplinary Activities) for deferred maintenance projects.

[4] MSO Special Projects funding contains support for the Windows on the Universe Center for Astronomy Outreach, ongoing activities at the WIYN telescope, and potential future participation in the U.S. Extremely Large Telescope program. Funding is also included for repairs and maintenane beyond regular O&M, as well as extraordinary inflationary impacts on O&M.

[5] Excluded is $2.50 million in Disaster Relief Supplemental Appropriations Act, 2023 funding designated for "damage to research facilities and scientific equipment in calendar year 2022, including related to the consequences of wildfires".

NOIRLab funding includes support for Rubin pre-operations, Gemini operations, and operations of the NOIRLab Base (MSO and CSDC) along with associated Special Projects under one overarching cooperative agreement with AURA.

- Rubin pre-operations funding began in FY 2018; more information on operations of Rubin (in partnership with DOE) can be found in the Rubin Observatory MREFC construction narrative.
- The FY 2024 Request for Gemini O&M covers NSF's partnership share of O&M costs as well as NSF's contribution to Gemini's Instrument Development Fund. Additional funding is provided under Special Projects for major maintenance and upgrade projects as needed.
- The FY 2024 Request for the Mid-Scale Observatories & CSDC funds the NOIRLab Directorate, supports O&M of KPNO and CTIO not otherwise funded by other entities or partners, and funds user support services, data archiving, and software development at CSDC.
- Special Projects include support of the NN-EXPLORE program at WIYN, refurbishment costs for the Windows on the Universe Center for Astronomy Outreach (renovation of the McMath-Pierce Solar telescope facility to create a new education center on Kitt peak), development of the U.S. ELT Program, and major maintenance and upgrade projects as needed.

Additional funding for deferred maintenance may be provided by MPS' Office of Strategic Initiatives.

Reviews and Reports

NSF has in the past conducted annual reviews of program operating plans, progress reports, and strategic planning documents for NOIRLab's component observatories, and now continues to do so

for the entire NOIRLab enterprise. Quarterly reports outlining progress against milestones and Key Performance Indicators are reviewed by NSF's NOIRLab IPT. In February 2021, NSF conducted its first external review of NOIRLab-wide performance and program operating plans. Audits and reviews of NOIRLab's annual budgets, indirect cost rates, overhead rates, and accounting systems are conducted annually or as needed by BFA. A NOIRLab-wide Business Systems Review is planned for the second half of FY 2023.

Renewal/Recompetition/Disposition

The latest recompetition of the O&M awards for MSO/CSDC and Gemini concluded separately in 2015, resulting in awards through the ends of FY 2020 and CY 2022, respectively. A renewal of funding for MSO, CSDC, and the NOIRLab Directorate for a further two years (FY 2021-FY 2022), authorized by the National Science Board (NSB) in July 2020, allowed NSF to synchronize the award periods for all existing programmatic components of NOIRLab, which also includes Rubin Observatory operations. In February 2022, NSF reviewed a five-year proposal for the renewal of all NOIRLab programs (MSO, CSDC, Gemini and Rubin Observatory operations) and in August 2022, the NSB authorized renewal of funding for the period FY 2023-FY 2027. Currently, there are no plans for disposition of any NOIRLab facilities, although evaluation of the future of current MSO facilities will be considered in the next award cycle.

OTHER FACILITIES FUNDING

Major Research Equipment and Facilities Construction Account Projects

The MREFC account supports the acquisition, construction, and commissioning of major facilities and larger mid-scale research infrastructure that provide unique capabilities at the frontiers of science and engineering. Projects supported by this account are intended to extend the boundaries of technology and open new avenues for discovery for the science and engineering community. Initial planning and design, and follow-on operations and maintenance costs of the facilities and infrastructure are provided through R&RA account.

For information on projects funded through this account, refer to the MREFC section of this Research Infrastructure Theme within the NSF-Wide Investments chapter.

Preconstruction Planning

Within the R&RA account, funds are provided for preconstruction studies for prospective major facility projects. This funding generally supports such activities as design, cost estimates, and other actions that prepare potential projects for oversight review, agency decision milestones, and potential implementation.

CROSS-THEME TOPICS

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

Ongoing Major Investments

STEM Education and Workforce

NATIONAL NANOTECHNOLOGY INITIATIVE (NNI)

National Nanotechnology Initiative Funding[1]

(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$39.95	$39.95	-	-	$39.95	$39.95
CISE	15.62	14.05	-	-	14.05	14.05
EDU	10.85	2.50	-	-	2.50	2.50
ENG	267.13	190.95	-	-	190.95	231.75
MPS	206.17	126.00	-	-	126.00	126.00
SBE	0.40	0.40	-	-	0.40	0.40
TIP	4.90	5.15	2.51	2.39	10.05	13.54
OISE	0.10	0.10	-	-	0.10	0.10
Total	**$545.12**	**$379.10**	**$2.51**	**$2.39**	**$384.00**	**$428.29**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actuals may be greater than future fiscal years due to the receipt of more meritorious programs than expected.

Overview

As indicated in the National Academies of Sciences, Engineering, and Medicine (NASEM) report *A Quadrennial Review of the National Nanotechnology Initiative*[1], "agencies should align the efforts of the NNI to deliver responsible and sustainable nanotechnology-based solutions that address the federal research and development priorities, which currently include security, artificial intelligence, quantum information sciences, manufacturing, bio-based materials, water, climate change, space travel, exploration, inhabitation, energy, medical innovations, and food and agriculture. [...] The NNI is widely viewed nationally and globally as a highly successful cross-disciplinary and interagency coordination effort — arguably the best modern example of such an effort in the United States." This document serves as the annual report for the NNI called for under the provisions of the 21st Century Nanotechnology Research and Development Act (15 USC §7501).

NSF's contribution to the multiagency NNI encompasses the systematic understanding, organization, manipulation, and control of matter at the atomic, molecular, and supramolecular levels in the size range of about 1 nanometer to 100 nanometers. Novel materials, devices, and systems—with their building blocks designed on the scale of nanometers—open new directions in science, engineering, and technology with potentially profound implications for society. An increased focus will be on using nanotechnology as a foundation and synergy with other emerging technologies, as well as for mitigating climate change and supporting foundational concepts for new vaccine development. NSF contributes to the NNI goals and five Program Component Areas (PCAs) outlined in the 2021 NNI

[1] www.nationalacademies.org/our-work/quadrennial-review-of-the-national-nanotechnology-initiative

Strategic Plan.[2] Funding by PCA is shown at the end of this discussion.

Goals

The shared vision of NNI agencies is a future in which the ability to understand and control matter at the nanoscale leads to ongoing revolutions in technology and industry that benefit society. NNI agencies collaborate to achieve five strategic goals:

- Ensure that the United States remains a world leader in nanotechnology research and development.
- Promote commercialization of nanotechnology R&D.
- Provide the infrastructure to sustainably support nanotechnology research, development, and deployment.
- Engage the public and expand the nanotechnology workforce.
- Ensure the responsible development of nanotechnology.

FY 2024 Funding

NSF supports nanoscale science and engineering throughout all the research and education directorates as a means to advance discovery, invention, and innovation and to integrate various fields of research. NNI enables increased interdisciplinarity in areas of atomic and molecular research through about 6,000 active awards with full or partial contents on nanoscale science and engineering (NSE). Approximately 10,000 students and teachers will be educated and trained in NSE in FY 2024.

Overall, NSF's total NNI funding in the FY 2024 Request is $428.29 million. Several new directions planned for FY 2024 include research connected to mitigation of climate change, advanced nanomanufacturing, AI and quantum systems, the bioeconomy, sustainability, advanced wireless, and quantum biology, as well as longer-term aspects of pandemic preparedness. Nanotechnology research will contribute to and synergize with NSF's research supporting emerging technologies such as advanced semiconductors. NSF sponsors an annual NSE grantee conference to assess the progress in nanotechnology and facilitate identification of new research directions.3

In FY 2024, NSF support will increasingly focus on convergence research and education activities in confluence with other priority areas. NSF will strengthen participation in innovation and translational programs such as Grant Opportunities for Academic Liaison with Industry (GOALI), Industry-University Cooperative Research Centers (IUCRC), the NSF Convergence Accelerator, NSF Regional Innovation Engines, and various translational programs led by the TIP directorate such as the Lab-to-Market Platform.

Various assessments and reports have assisted with informing plans for NNI going into the future. NSF sponsored an international study on long-term research entitled Nanotechnology Research Directions for Societal Needs in 2020,4 which provides a vision of the field in 2020 and beyond. With the National Institutes of Health (NIH), National Aeronautics and Space Administration (NASA),

[2] www.nano.gov/2021strategicplan

[3] 2021 Nanoscale Science and Engineering Grantees Conference: www.nsf.gov/crssprgm/nano/ and www.nseresearch.org/2022/

[4]NSF/WTEC 2010, Springer, available on www.nsf.gov/crssprgm/nano/ and http://scienceus.org/wtec/docs/nano2.pdf

Environmental Protection Agency (EPA), Office of Naval Research (ONR), and the U.S. Department of Agriculture (USDA), NSF co-sponsored the study entitled Converging Knowledge, Technology, and Society5 evaluating the convergence of nanotechnology with other emerging areas by 2030. Other reports address aspects of fundamental research for energy-efficient sensing and computing, data storage, real-time communication ecosystem, multi-level and scalable security, a new fabrication paradigm, and insight computing.[6,7,8]

Investments by Program Component Area

PCAs are the major subject areas of relevance to the NNI agencies, where progress is critical to achieving NNI's goals and to realizing its vision.[9] NSF supports funding in all five PCAs.

NNI Funding by Program Component Area[1]

(Dollars in Millions)

			Disaster Relief Supplemental			
	FY 2022 Actual[2]	FY 2023 Estimate	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request
1. Foundational Research	$329.76	$241.35	$1.00	$0.95	$243.30	$259.00
2. Nanotechnology-Enabled Applications, Devices, & Systems	139.51	81.76	1.13	1.08	83.97	110.29
3. Research Infrastructure and Instrumentation	27.68	22.73	0.23	0.22	23.18	21.00
4. Education and Workforce Development	30.85	19.00			19.00	24.00
5. Responsible Development	17.33	14.26	0.15	0.14	14.55	14.00
Total	**$545.12**	**$379.10**	**$2.51**	**$2.39**	**$384.00**	**$428.29**

[1] 10 percent of PCA1 and 5 percent 0f PCA2 in FY 2024 will be dedicated to the National Nanotechnology Challenge nano4EARTH.

[2] FY 2022 Actuals are greater than future fiscal years due to the receipt of more meritorious programs than expected.

PCA 1: Foundational Research

Funded at $259.0 million, this PCA supports discovery and development of fundamental knowledge pertaining to new phenomena in the physical, biological, and engineering sciences that occur at the nanoscale. Also included is support for research to understand scientific and engineering principles related to nanoscale systems, structures, processes, and mechanisms; research on the discovery and synthesis of novel nanoscale and nanostructured materials including biomaterials and modular structures; quantum biology for understanding natural phenomena and interfaces; water nanofiltration systems; and research directed at identifying and quantifying the broad implications of nanotechnology for society, including social, economic, ethical, and legal implications. It includes foundational research on climate change understanding and mitigation (contributing about 10 percent of PCA 1 to the nanotechnology challenge nano4EARTH[10]), Predictive Intelligence for Pandemic Prevention, and nano-Ethical, Legal and Societal Implications (ELSI). Most of the research is

[5] NSF/WTEC 2013, Springer, available on www.nsf.gov/crssprgm/nano/ and http://scienceus.org/wtec/docs/nbic2.pdf

[6] www.nsf.gov/crssprgm/nano/

[7] www.src.org/nri/energy-efficient-computing-workshop.pdf

[8] www.semiconductors.org/issues/research/research/

[9] www.nano.gov/about-nni/what/vision-goals

[10] www.nano.gov/nano4EARTH

sponsored in individual and small group research across NSF directorates. A subset of Engineering Research Centers (ERC), Science and Technology Centers (STCs), Centers for Chemical Innovation (CCIs) and other center programs support various aspects of nanoscale science and engineering. About 60 percent of the Materials Research Science and Engineering Centers (MRSECs) pursue NSE-related fundamental research.

NSF has invested in understanding the nanoscale machines that make up the nucleus of a cell and control cell function through its programs in Understanding the Rules of Life, the Physics Frontiers Center program, and core programs in Molecular and Cellular Biosciences (Genetic Mechanisms) as well as Chemistry (Chemistry of Living Processes). In FY 2024, NSF will also continue its efforts in nanobiotechnology associated with synthetic biology and synthetic cells through core programs in BIO - Molecular and Cellular Biosciences (MCB) and ENG - Chemical, Bioengineering, Environmental, and Transportation Systems (CBET).

This PCA includes foundational research supporting several thematic areas:

- *Sustainable Nanomanufacturing:* Investments support foundational concepts for new nanomanufacturing methods at the confluence with digitization, biotechnology, AI, and cognitive sciences. Research in synthetic cells will lead to scalable and reproducible cell and organ production for biomanufacturing and biomedicine applications. Another new direction is manufacturing of quantum systems, nanomachines and nano biostructures. Methods for nanomanufacturing design are in synergy with the Materials Genome Initiative.
- *Nanoelectronics and Semiconductors:* Research is aimed at discovering and using novel nanoscale fabrication processes and innovative concepts to produce revolutionary materials, devices, systems, and architectures to advance the field of electronics beyond Moore's Law. NSF will continue related investments in quantum systems and advanced wireless technology.
- *Nanotechnology for Sensors and Sensors for Nanotechnology*: Research is aimed at the use of nanoscale principles and materials to build more sensitive, specific, and adaptable sensors and the development of new sensors to detect engineered nanomaterials across their life cycles to assess their potential impacts. It supports materials and technologies that enable new sensing of biological, chemical, and nanoscale materials. Programs on biosensing and biophotonics in CBET support this effort.
- *Nanotechnology-Inspired for Future Computing*: Research is related to "Brain-like Computing" and "Intelligent Cognitive Assistants" areas. An example of an active center is the STC on Integrated Quantum Materials at Harvard University and the MRSEC on Quantum and Spin Phenomena in Nanomagnetic Structures at the University of Nebraska, Lincoln.

PCA 2: Nanotechnology-Enabled Applications, Devices, and Systems

The FY 2024 Request includes $110.29 million for research that applies the principles of nanoscale science and engineering to create novel devices and systems, to achieve improved performance or new functionality, including metrology, scale up, manufacturing technology, and nanoscale reference materials and standards. Core programs in the ENG, MPS, and CISE directorates support development of new principles, design methods, and constructive solutions for nanomaterials and nanodevices. A special focus is on smart, autonomous nanoscale-based devices and systems. PCA 2 includes applications-, device-, or systems-focused research related to Sustainable Nanomanufacturing, Nanoelectronics (semiconductors), and Nanotechnology for Sensors and Sensors for Nanotechnology. The Future Manufacturing program, which began in 2020, will continue into 2023

and 2024.[11] The goal of Future Manufacturing is to support fundamental research and education of a future workforce to overcome scientific, technological, educational, economic, and social barriers to enable new manufacturing capabilities that do not exist today. Support for climate change mitigation contributes about 5% of PCA 2 to the nanotechnology challenge nano4EARTH. Besides core nanoscience-related programs on water filtration and applications, the Nanosystems ERC for Nanotechnology Enabled Water Treatment Systems (NEWT), led by Rice University and funded between 2015 and 2024, aims to develop high-performance water treatment systems that will broaden access to clean drinking water from a variety of unconventional sources (briny well water, seawater, wastewater), and enable industrial wastewater reuse at remote locations such as oil and gas fields. Other ERCs do research in portable nanosensors, new nanomanufacturing processes, and new nano-electronic materials. IUCRCs focus on solar energy conversion, metrology, novel catalysts and bioplastics, novel high voltage/temperature materials and structures, and other applications.

PCA 3: Research Infrastructure and Instrumentation

The FY 2024 Request includes $21.0 million for the establishment and operation of user facilities and networks, acquisition of major instrumentation, workforce development, and other activities that develop, support, or enhance the Nation's physical or workforce infrastructure for nanoscale science, engineering, and technology. This PCA includes research pertaining to the tools needed to advance nanotechnology research and commercialization, including next-generation instrumentation for characterization, measurement, synthesis, and design of materials, structures, devices, and systems.

NSF has funded awards totaling about $16.0 million per year for the National Nanotechnology Coordinated Infrastructure (NNCI) sites for FY 2015–2024. Other STCs, ERCs, CCIs, nano-HUB nodes, and MRSECs have a focus on supporting the NNI, including the Center for Cellular Construction at the University of California-San Francisco (annual award since 2016 of approximately $5 million per year), two Nanosystems ERCs, one each on nanobiotechnology and cell technology, and a CCI at University of Wisconsin (annual award of $4.0 million per year) which investigates the fundamental molecular mechanisms by which nanoparticles interact with biological systems. The funding also includes workforce development activities at these centers and sites. NSF will increase coordinated research on its Mid-scale Research Infrastructure priority area. The Major Research Instrumentation (MRI) program[12] serves to increase access to multi-user scientific and engineering instrumentation, including instrumentation needed for NNI activities, for research and research training in the Nation's institutions of higher education and not-for-profit scientific/engineering research organizations.

PCA 4. Education and Workforce Development

In FY 2024, NSF will fund education and workforce development activities in all areas of nanoscale science and engineering, including engaging the public, at $24.0 million. Typical activities supported by EDU divisions, ENG's Division of Engineering Education and Centers, and other divisions are fellowships, single investigator awards, and centers.

The NSF INTERN program[13] supports about 75 NSE-related internships for students in industry and government labs. Illustrations of projects at the undergraduate and graduate levels are "Supporting

[11] https://beta.nsf.gov/funding/opportunities/national-science-foundation-future-semiconductor
[12] www.nsf.gov/funding/pgm_summ.jsp?pims_id=5260
[13] www.nsf.gov/INTERN

Micro and Nano Technicians through Hybrid Teaching Methods,"[14] the Nanotechnology Applications and Career Knowledge (NACK) Resource Center,[15] the Micro Nano Technology Education Center (MNT-EC),[16] and "Nano-Makerspace to Make and Explore in the World of the Small."[17] The Boston Museum of Science hosts a nationwide NSE communication competition for students.[18]

PCA 5. Responsible Development

In FY 2024, NSF will continue its funding for Environment, Health, and Safety (EHS), ELSI, and diversity, equity, inclusion, and access, as well as nanotechnology research integrity, safety, and reproducibility at $14.0 million. Requests for research are primarily directed at understanding nano-bio phenomena and processes, as well as environment, health, societal, and safety implications and methods for reducing the respective risks of nanotechnology development. ENG's nano EHS program has changed to *Nanoscale Interactions*. MPS supports the CCI: Center for Sustainable Nanotechnology at the University of Wisconsin.[19] Support will be increased for diversity, equity, inclusion and access for underrepresented groups, women and persons with disabilities interested in nanoscale science and engineering, for various knowledge and technology fields to be explored in conjunction with nanotechnology, and for broad geographical representation across the U.S.

Coordination with Other Agencies

NSF's NNI activities are coordinated with 20 other departments, of which several have multiple participating agencies, through the National Science and Technology Council subcommittee on Nanoscale Science, Engineering, and Technology (NSTC/NSET). These agencies also partner with NSF to sponsor joint funding opportunities and workshops on nanotechnology research directions and send representatives to participate in grantees conferences. Some specific coordination efforts are:

- Nano4EARTH partnerships with all NNI agencies, including EPA, FDA, and DOE.
- Sustainable Nanomanufacturing—NSF, NIST, Department of Energy (DOE), EPA, NIH, National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), USDA/Food Safety (FS).
- Nanoelectronics and semiconductors—NSF, NIST, Department of Defense (DOD), DOE, Intelligence Community (IC)/Director of National Intelligence (DNI), and NASA.
- NSF collaborates with other 20 other agencies in the NNI task force on "Nanoplastics".
- NNCI and NCN centers and networks—NSF, DOD, NASA, DOE, and NIH.
- Nanosensors—NSF, NIOSH, NIH, FDA, NIST, DOD, NASA, and EPA.
- Nano-EHS collaboration in the Nanotechnology Environment, Health, and safety WG.
- INTERN program supports NSE-related internships at DOD/AFRL.
- OECD (Working Group on Bio, Nano, and other Converging Technologies)

[14] Award DUE-2100402 (https://nsf.gov/awardsearch/showAward?AWD_ID=2100402)
[15] Award DUE-2000725 (https://nsf.gov/awardsearch/showAward?AWD_ID=2000725)
[16] Award DUE-2000281 (https://nsf.gov/awardsearch/showAward?AWD_ID=2000281)
[17] Award DUE-1723511 (https://nsf.gov/awardsearch/showAward?AWD_ID=1723511)
[18] www.mos.org/quantum-matters-competition
[19] https://susnano.wisc.edu/

NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD)

Networking and Information Technology Research and Development Funding[1]

(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$79.00	$79.00	-	-	$79.00	$81.50
CISE	1,015.57	1,010.57	40.00	-	1,050.57	1,172.14
EDU	17.65	22.09	-	-	22.09	22.09
ENG	167.42	156.45	-	-	156.45	179.26
GEO Programs	23.00	27.00	-	-	27.00	30.00
MPS	345.76	224.15	-	-	224.15	239.34
SBE	41.89	30.94	2.00	-	32.94	38.94
TIP	224.10	196.13	95.91	91.53	383.57	516.76
IA	14.30	1.00	-	-	1.00	1.00
Total	**$1,928.69**	**$1,747.33**	**$137.91**	**$91.53**	**$1,976.77**	**$2,281.03**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actuals may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Overview

NSF is a primary supporter of the NITRD program, and NSF's NITRD portfolio includes all research, research infrastructure, and education investments in CISE, as well as contributions from all other directorates across the agency, enabling investments in every NITRD Program Component Area (PCA). The NSF assistant director for CISE is co-chair of the NITRD Subcommittee of the National Science and Technology Council's (NSTC) Committee on the Science and Technology Enterprise. NSF leadership also co-chair the Machine Learning and Artificial Intelligence (MLAI) as well as the Future Advanced Computing Ecosystem (FACE) Subcommittees, enabling close coordination between NITRD, MLAI, and FACE.

Through NITRD, NSF coordinates its investments in networking and information technology research and development across more than 20 federal departments, agencies, and offices. NSF staff work in close collaboration with other NITRD agencies and participate in all NITRD interagency working groups, including at the co-chair level in most. As noted above, NSF also facilitates interaction between NITRD and other bodies of the NSTC as appropriate.

FY 2024 NITRD Funding

NSF's FY 2024 Budget Request includes support for NITRD at a level of $2,281.03 million. NITRD activities represent approximately 20.2 percent of NSF's FY 2024 Budget Request to Congress.

Investments by Program Component Area (PCA)

The PCAs are reviewed annually to ensure they remain relevant and reflect the most up-to-date R&D needs of the Nation.
The following information focuses on FY 2024 NSF investments, both new and continuing, by PCA.

NITRD Funding by Program Component Area
(Dollars in Millions)

			Disaster Relief Supplemental			
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request
Advanced Communication Networks and Systems (ACNS)	$212.62	$197.23	$7.64	$7.29	$212.16	$237.53
Artificial Intelligence R&D (AI)	506.53	391.78	26.64	24.48	442.90	531.34
Computing-Enabled Human Interaction, Comm. Aug. (CHuman)	111.05	89.65	1.18	1.13	91.96	108.88
Computing-Enabled Networked Physical Systems (CNPS)	82.91	107.20	16.34	15.59	139.13	166.56
Cyber Security and Privacy (CSP)	120.04	108.58	9.25	3.58	121.41	134.25
Education and Workforce (EdW)	95.64	102.97	12.53	6.71	122.21	143.12
Enabling-R&D for High-Capability Computing Systems (EHCS)	179.96	165.62	0.17	0.16	165.95	186.33
Electronics for Networking and Information Technology (ENIT)	72.79	78.29	11.31	10.79	100.39	119.11
High Capability Computing Infrastructure and Applications (HCIA)	209.57	178.79	30.61	0.58	209.98	228.86
Intelligent Robotics and Autonomous Systems (IRAS)	48.14	48.98	4.77	4.55	58.30	69.91
Large-Scale Data Management and Analysis (LSDMA)	222.15	206.83	14.45	13.79	235.07	265.35
Software Productivity, Sustainability, and Quality (SPSQ)	67.30	71.41	3.02	2.88	77.31	89.79
Total	**$1,928.69**	**$1,747.33**	**$137.91**	**$91.53**	**$1,976.77**	**$2,281.03**

[1] FY 2022 Actuals may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Advanced Communication Networks and Systems (ACNS)

ACNS will include CISE investments in the NSF-wide Smart and Connected Communities (S&CC) program. ACNS will also include NSF investments in the Spectrum Innovation Initiative supporting fundamental spectrum research in increased spectrum efficiencies, flexibility, and adaptability and leading to the creation of advanced wireless technologies and systems beyond 5G. Additionally, in collaboration with other federal agencies and the private sector, ACNS will include NSF investments on Resilient and Intelligent Next-Generation (NextG) Systems (RINGS), transforming emerging NextG wireless and mobile communication, networking, sensing, and computing. Finally, ANCS will include NSF investments in federating an open-access plane across the four Platforms for Advanced Wireless Research, creating an interconnected national network for testing and validation of emerging wireless concepts ranging from dynamic spectrum sharing to measurement and monitoring.

AI R&D

AI R&D will include investments in fundamental research advancing AI. A key focal point of investment in AI R&D will be support for National AI Research Institutes. These center-scale projects will advance foundational research; leverage use-inspired research; build the next-generation of talent; mobilize multidisciplinary groups of scientists, engineers, and educators; and serve as a nexus point for multisector collaborative efforts. The National AI Research Institutes will fill a major gap in America's AI research and education portfolio by accelerating AI innovations, training AI researchers and innovators, and transitioning outcomes across a range of sectors. In addition, through the Expanding AI Innovation through Capacity Building and Partnerships (ExpandAI) program NSF will significantly broaden participation in AI research, education, and workforce development through capacity

development projects and through partnerships within the National AI Research Institutes ecosystem.

AI R&D will also include the initial steps toward implementation of the recommendations of the National AI Research Resource (NAIRR) Task Force, a Congressionally chartered Federal Advisory Committee charged with developing a roadmap and implementation plan for a shared computing and data infrastructure that would provide the Nation's AI researchers and students with access to a holistic ecosystem of resources to fuel AI discovery and innovation.

This PCA also includes CISE investments in foundational research in AI, including knowledge representation and reasoning, multi-agent systems, planning, machine and deep learning, computer vision, and human language technologies; EDU investments in AI-enabled teaching and learning systems; ENG investments in advanced manufacturing and the mind, machine, and motor nexus; SBE investments to integrate machine learning advances with learning mechanisms developed in cognitive science, develop new statistical inferences and algorithms for the analysis of large data sets, and understand the legal and ethical implications of AI; BIO investments in ML, natural language processing, computer vision, and genetic algorithms applied to solve problems such as genome sequence alignment, prediction of protein structure, reconstruction of evolutionary relationships, extraction of quantitative information from multi-media data sources, and the bioeconomy more generally; MPS investments in ML, deep learning, and neural networks through the Condensed Matter and Materials Theory, Designing Materials to Revolutionize and Engineer our Future, and Materials Research Science and Engineering Centers programs; and TIP investments in Regional Innovation Engines, which leverage multiple disciplines, institutions, and sectors to advance emerging technologies, including AI, and address major societal and economic challenges in areas such as the bioeconomy and climate change.

Computing-Enabled Human Interaction, Communications, Augmentation (CHuman)

CHuman will include investments to support educating and re-educating learners of all ages and career stages (American students, teachers, and workers) in STEM content areas through emerging technologies. CHuman will also include investments in the Smart Health and Biomedical Research in the Era of AI and Advanced Data Science program, which will support the development of transformative high-risk, high-reward advances in computer and information science, engineering, mathematics, statistics, behavioral and/or cognitive research to address pressing questions in the biomedical and public health communities. In addition, CHuman will include SBE investments on cyberinfrastructure related to its three major ongoing social science surveys (American National Election Studies, the Panel Study of Income Dynamics, and the General Social Survey), which will enable examination of American competitiveness, security, economic development, and well-being.

Computing-Enabled Networked Physical Systems (CNPS)

CNPS will include CISE and ENG investments in Cyber-Physical Systems, enabling foundational interdisciplinary research and education in adaptive and pervasive smart systems supporting applications such as the smart grid, intelligent transportation systems, and medical devices. It will also include investments in the NSF-wide S&CC program, which will support interdisciplinary, integrative research that deeply engages local residents, stakeholders, and governments to improve understanding, design, and long-term sustainability of intelligent infrastructure for American communities, thereby leading to enhanced quality of life for residents. CNPS also includes TIP investments in the Convergence Accelerator (CA) which accelerates use-inspired, solutions-oriented research and piloting in specific areas of national importance; in FY 2023, the CA will launch a regional

approach supporting regional cohorts pursuing location-specific challenges in agriculture, energy, and transportation, to name a few. CNPS will additionally include BIO investments in expanding and enhancing access to the national resource of digital biological and paleontological data and ENG investments in advanced and future manufacturing, including cyber-manufacturing.

Cyber Security and Privacy (CSP)

CSP will include investments in the NSF-wide SaTC program and other related cybersecurity and privacy research. The investments in SaTC in particular will support foundational research necessary to ensure society's ubiquitous computing and communication systems are resistant to cyber-attacks and associated vulnerabilities, while enabling and preserving privacy and trust. SaTC emphases will span AI and ML, including adversarial ML; implications of quantum computing for security, including post-quantum cryptography; architectures and technologies for protecting cyberspace from increasingly sophisticated connected devices; and security and privacy aspects of smart infrastructure including the Internet of Things. In addition, CSP includes investments to transition research to practice, such as approaches to harden privacy-enhancing technologies led by TIP in collaboration with CISE and SBE. CSP also includes NSF investments in programs that strengthen pathways for the national cybersecurity workforce, including support for innovation at the K-12 level, community colleges, and four-year universities.

Education and Workforce (EdW)

EdW will include collaboration between CISE and EDU on investments across all education levels, including at the undergraduate level through IUSE: Computing in Undergraduate Education, which supports efforts to re-envision the role of computing in interdisciplinary collaboration within American institutions of higher education. CISE and EDU will also invest at the K-12 levels through Computer Science for All: Researcher-Practitioner Partnerships, which supports the R&D needed to bring computer science and computational thinking to all schools at the preK-12 levels. CISE and EDU will also support workforce development in cybersecurity, enabling a growing cadre of researchers, educators, and practitioners, and allowing all Americans to understand the security and privacy of the digital systems on which their lives increasingly depend. As part of this investment, EdW will fund programs in CISE and EDU that strengthen pathways for the national cybersecurity workforce, including support for innovation at the K-12 level, in community colleges, and at four-year universities. EdW will additionally include BIO investments in advancing America's ability to incorporate and apply biological knowledge to economic development and other issues of societal importance, and TIP investments that offer experiential and entrepreneurial opportunities to students and researchers at all levels pursuing studies in emerging technologies. In general, EdW investments will continue to promote equity through a broad suite of activities that support broadening participation in STEM research and education, and that study the causes of, impacts on, and practices for addressing inequity in STEM participation.

Enabling-R&D for High-Capability Computing Systems (EHCS)

In alignment with the FACE Strategic Plan[1], EHCS will include investments which support (i) research advances in new computing technologies, architectures, and platforms for the future; (ii) the development and deployment of advanced computing systems and services, while maximizing the benefits of these systems and services through deep integration with science and engineering research; and (iii) formulation of approaches for the federation of advanced computing systems and

[1] www.nitrd.gov/pubs/Future-Advanced-Computing-Ecosystem-Strategic-Plan-Nov-2020.pdf

services to realize a National Discovery Cloud for Climate (NDC-C). EHCS will also include CISE and MPS investments that advance computational algorithms and data analytics to address scientific and engineering opportunities presented by data emerging from digital and observational data sources. It will also include CISE and MPS investments in fundamental research on innovative materials integration and novel phenomena associated with quantum information science, optical computing, and neuro-computing.

Electronics for Networking and Information Technology (ENIT)
ENIT will include CISE, ENG, and MPS investments in biological computation, nanoscale science and engineering, quantum information science and engineering, and neuromorphic computing as well as other disruptive technologies. ENIT will also include CISE, ENG, and MPS investments in the underlying fundamental physical and materials science; design and design automation of electronic devices, circuits, and systems, systems architectures, and related software; and the fabrication and characterization of tools and facilities required for advanced microelectronics and semiconductor technologies. In addition, in collaboration with private industry, ENIT will include CISE, ENG, MPS, and TIP investments that advance research on the design and manufacture of future semiconductor technologies.

High Capability Computing Infrastructure and Applications (HCIA)
HCIA will include CISE investments on the development and deployment of software and algorithms for advanced computing systems and services. HCIA will include CISE investments in the NDC-C that will federate access to compute resources from multiple sources, including NSF-funded advanced computing resources, edge resources located at NSF major facilities, and at other compute- and data-intensive NSF research facilities, as well as commercial cloud computing resources. These investments will also build on CISE and MPS investments in new computational methods, algorithms, scientific databases, and other computational tools to support researchers in the mathematical and physical sciences as well as engineering through programs such as Computational and Data-Enabled Science and Engineering; CISE and GEO investments in advanced cyberinfrastructure for the geosciences; GEO investments in the operations and maintenance of the National Center for Atmospheric Research's Wyoming Supercomputer facility and associated modeling efforts; and BIO investments in the application of advanced computing to a range of grand challenge problems in the biological sciences, including the genotype-to-phenotype relationship, and the environmental sciences. HCIA investments will further understanding of climate science and clean-energy technologies by enabling data science, artificial intelligence and machine learning, and predictive and high-end computational modeling and simulation. HCIA will also include initial steps toward implementation of the recommendations of the NAIRR Task Force.

Intelligent Robotics and Autonomous Systems (IRAS)
IRAS will include CISE and ENG investments in robotics and autonomous systems that exhibit significant levels of both computational capability and physical complexity, including research related to the design, application, and use of robotics to augment human function, promote human-robot interaction, and increase robot autonomy. As part of the next generation of robotics, collaborative robotics (co-robot) systems, i.e., robotic systems that work beside or cooperatively with people, will be characterized by their flexibility and resourcefulness. They will use a variety of modeling or reasoning approaches, along with real-time, real-world data, demonstrating a level of intelligence and adaptability seen in humans and animals. As development of this next generation of co-robotics proceeds in application domains such as advanced manufacturing, emergency response, and health

care, complete confidence in these systems becomes increasingly important.

Large-Scale Data Management and Analysis (LSDMA)

LSDMA will include CISE investments in the development of a comprehensive, scalable data infrastructure, as well as CISE investments in the NDC-C that will incorporate systems to curate, federate, and provide access to data from multiple sources, be they NSF-funded large facilities, resources from industry/non-profits, or the data contribution of individual researchers, to enable new scientific discoveries by supporting the broad examination and reexamination of collected data, and the scientific analysis of combinations of heterogeneous data. LSDMA will additionally include ENG investments in cyberinfrastructure for the Natural Hazards Engineering Research Infrastructure, which provides access to and storage and analysis of massive amounts of data related to natural disasters; MPS investments in Data-Driven Discovery Science in Chemistry as well as Computational Mathematics; SBE investments in data science and associated research infrastructure; and BIO investments in integrative modeling of complex biological processes.

Software Productivity, Sustainability and Quality (SPSQ)

SPSQ will include investments in the software foundations within CISE, as well as new thinking, paradigms, and practices in developing and using software that is robust, reliable, usable, and sustainable through the NSF-wide Cyberinfrastructure for Sustained Scientific Innovation (CSSI) program. SPSQ will include CISE investments in the NDC-C that will democratize access to advanced compute, data, software, and networking resources. SPSQ will also include investments in NSF-wide programs, such as the interagency and international Collaborative Research in Computational Neuroscience (CRCNS). For example, through CRCNS, BIO will fund research involving the development of software and other computational tools to advance biological knowledge and computational innovations.

UPDATE ON NSF'S BIG IDEAS

NSF's Bigs Ideas, first put forth in FY 2017, ended as a unifying concept in FY 2023 as planned. Investments in these forward-looking research categories across the R&RA, EDU, and MREFC accounts provided the groundwork for many new successes. Most of the Big Ideas will continue as core research programs or be superseded by new but related efforts. For example, while the *Understanding Rules of Life (URoL)* Big Idea has ended, in FY 2024 the BIO Directorate will build upon the knowledge gained through URoL to create a new effort focused on Using the Rules of Life, which will support convergent, use-inspired research in biotechnology. The data-driven discovery, workforce development, and community-building activities supported by the *Harnessing the Data Revolution* Big Idea lay a foundation for, and will naturally feed into, FY 2024 investments in programs such as Accelerating Computation-Enabled Discovery. *The Future of Work at the Human Technology Frontier* (FW-HTF) Big Idea will sunset, but new investments connected to FW-HTF concepts will be made as components of new and existing activities, such as Future Manufacturing, clean energy research hubs, circular economy engineering and science, and sustainable regional systems research.

Growing Convergence Research and *Mid-scale Research Infrastructure Track 1* within Integrative Activities, and *Mid-scale Research Infrastructure Track 2* within the MREFC account will continue as independent programs. *Navigating the New Arctic* within the GEO Directorate will be superseded by a new effort which builds on the core success of engaging with local communities and broadens the scope to look at resilient futures for these communities. *Windows on the Universe* will continue as a meta-program between the MPS and GEO Directorates to fund innovative investments in multi-messenger astrophysics. Q*uantum Leap* was previously superseded by the QIS program. *NSF INCLUDES,* renamed in the CHIPS & Science Act of 2022 as the *Eddie Bernice Johnson INCLUDES Initiative*, continues to advance equity, inclusion, and broaden participation in STEM at scale by providing research, sustainable activities, and infrastructure for collaborative systems change through the EDU Account.

NATIONAL SCIENCE FOUNDATION CENTERS

NSF supports a variety of centers programs that contribute to the Foundation's mission and vision. Centers exploit opportunities in science, engineering, and technology in which the complexity of the research program or the resources needed to solve the problem require the advantages of scope, scale, duration, equipment, facilities, and students. Centers are a principal means by which NSF fosters interdisciplinary research.

NSF Centers
(Dollars in Millions)

	Program Initiation	No. of Ctrs. in FY 2022	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request
AI Research Institutes	2020	14	$53.88	$52.01	-	-	$52.01	$73.98
Biology Integration Institutes	2020	14	25.90	35.20	-	-	35.20	53.68
Centers for Analysis & Synthesis	1995	2	1.50	2.50	-	-	2.50	6.50
Centers for Chemical Innovation	1998	9	27.46	27.70	-	-	27.70	27.70
Engineering Research Centers	1985	17	70.47	68.70	-	-	68.70	86.09
Materials Centers	1994	23	53.27	56.80	-	-	56.80	57.00
Quantum Leap Challenge Insts	2020	5	58.37	21.85	-	-	21.85	20.00
NSF Regional Innovation Engines	2023	0	0.71	-	-	200.00	200.00	300.00
Science & Technology Centers	1987	18	55.99	50.60	24.00	-	74.60	74.60
Spectrum Innovation Initiative Ctr.	2021	1	17.00	17.00	-	-	17.00	17.00
Total			**$364.55**	**$332.36**	**$24.00**	**$200.00**	**$556.36**	**$716.55**

About NSF Centers Programs

Artificial Intelligence Research Institutes – multi-directorate

The FY 2024 Request of $73.98 million will support up to 22 National AI Research Institutes—five institutes launched in FY 2020, nine awarded in FY 2021, six additional institutes planned in FY 2023, and up to two additional institutes planned in FY 2024. In addition, five institutes (two awarded in FY 2020, two awarded in FY 2021, and one planned in FY 2023) are wholly funded by the U.S. Department of Agriculture National Institute of Food and Agriculture (USDA NIFA).

The National AI Research Institutes program, a multisector collaboration among government, industry, and academia, supports multidisciplinary advances on challenges in both foundational and use-inspired AI research. Each funded institute has three missions: (1) to advance fundamental knowledge of AI; (2) to advance use-inspired work on using AI to solve real-world problems of importance to the U.S. economy; and (3) to grow the U.S. AI workforce and build pathways for students from diverse backgrounds. They serve as nexus points for academic, government, and industry interaction, and integrate research with the development of the next-generation AI workforce. A key motivation for the program is to maintain and grow U.S. leadership and competitiveness in AI at a time when other nations are making significant investments in the field. The National AI Research Institutes program is led by CISE and includes contributions from all NSF directorates along with external partners, including federal agencies and industry. Each year, the program solicits proposals that respond to one of a given set of themes. Some of these themes have included Foundations of Machine Learning; Trustworthy AI; AI-Driven Innovation in Agriculture and the Food System; AI-Augmented Learning; AI for Accelerating Molecular Synthesis and Manufacturing; Human-AI

Interaction and Collaboration; AI and Advanced Cyberinfrastructure; Advances in AI and Computer and Network Systems; and others. Each institute is funded at up to $4.0 million per year for up to five years. The latest solicitation issued in summer 2021 for awards in FY 2023 continues the ongoing collaboration with USDA NIFA as well as new partnerships with the DOD Office of the Undersecretary of Defense for Research and Engineering, the National Institute of Standards and Technology, the U.S. Department of Education Institute for Education Sciences, and IBM.

Biology Integration Institutes – BIO

The FY 2024 Request of $53.68 million is expected to support 20 Biology Integration Institutes (BII). This will include fifteen continuing BII awards and five new awards.

The BII program supports collaborative teams of researchers investigating frontier questions about life that span multiple disciplines within and beyond the biological sciences. The goal is to foster creative integration of diverse fields using innovative experimental, theoretical, and modeling approaches to discover underlying principles operating across multiple levels of life; from molecules to cells, organisms, species, and ecosystems. Each institute has unique research themes centered around a compelling biological question poised for breakthroughs by collaboration across biological disciplines. The themes address fundamental and use-inspired research that serve to advance discovery and understanding in the life sciences and expand capabilities in biotechnology to modify and utilize living systems. Outcomes from BII awards will foster innovation and applications that benefit U.S. security and health, mitigate the impacts of climate change, and spur economic growth.

BII awards support team-science and training environments that are fully integrated with the research theme and conducive to addressing complex science challenges, leveraging new ideas, expertise and infrastructure, and exploration of new modes of collaboration, which will prepare the next generation of biological scientists to pursue multidisciplinary research throughout their careers. Typically, BII awards bring together multiple organizations to leverage interdisciplinary talent and infrastructure, and to broaden participation of undergraduate and graduate students from underrepresented groups in the life sciences. In this way, BII awards build a diverse and inclusive workforce that can address the challenges of climate change and emerging infectious diseases, and that fulfill the needs of an expanding U.S. bioeconomy.

Centers for Analysis and Synthesis - BIO

The FY 2024 Request of $6.50 million for Centers for Analysis and Synthesis is expected to provide continuing support ($4.50 million) for a center in environmental science and eco-forecasting, awarded in FY 2022. The Center will develop the teams, concepts, resources, and expertise to enable inclusive, effective, and coordinated efforts to answer broad scientific questions that emerge at interfaces between biological and environmental sciences, including climate change, land use change, biodiversity loss, and ecosystem services. The center will leverage data being provided by the National Ecological Observatory Network (NEON), Long-Term Ecological Research (LTER) and other environmental observatories and databases to support community efforts in ecological modeling to develop a national capability for eco-forecasting. A new funding competition for BIO's Center for Analysis and Synthesis in molecular and cellular biosciences is being planned for completion in FY 2024 with an initial year funding of $2.0 million. Its goal is to achieve a comprehensive understanding of cell biology that relates molecular structure, function and interactions to cellular properties in ways that predict the emergent behavior of cells in a dynamic environment. The Center will aim to provide a catalytic role to advance the integrated knowledge of the workings of cells, metabolism, information

processing, growth, senescence, proliferation and differentiation by analysis and synthesis of diverse molecular and cellular data. It will also catalyze a culture of data sharing, standards development and reuse for this subdiscipline of biology. In FY 2024, the initial stages of a competition for a Center for Analysis and Synthesis in the area of integrative organismal systems and organismal resilience will begin. The resulting award is planned to begin in FY 2025.

Centers for Chemical Innovation - MPS

The FY 2024 Request of $27.70 million will fund up to seven Phase II Centers for Chemical Innovation (CCI). This includes up to six continuing centers and one new center. Each Phase II center is slated to be funded at $4.0 million per year (five-year awards with potential for renewal up to a total of ten years). An eighth center remains active and will sunset in FY 2024.

CCIs are developed through a two-phase process. Phase I CCIs conduct research, pilot broader impact activities, and complete key center development activities before submitting their Phase II proposal. There are currently nine Phase I awards supported by the Division of Chemistry.

CCIs focus on major, long-term fundamental chemical research challenges. CCIs are agile, collaborative entities that respond rapidly to emerging opportunities by integrating research with innovation, higher education, broadening participation, and informal science communication. The themes of the CCIs are varied and include Administration priorities such as clean energy technologies, climate solution, AI, QIS, biotechnology, advanced manufacturing, plastics recycling, and sustainable chemistry, along with training for students at all levels. CCIs are also actively engaged in knowledge transfer to industry and the commercialization of their discoveries and new technologies. Several CCIs are studying various aspects of sustainability and clean energy technologies: the Center for Sustainable Nanotechnology (CSN) is examining how technologically important nanoparticles found in batteries interact with biological systems and how those nanoparticles can be redesigned to be environmentally benign; the Center for Synthetic Organic Electrochemistry (CSOE) is developing new electrosynthesis reactions that are safer, more energy-efficient, and generate less waste; and the Center for Sustainable Polymers (CSP) works on the discovery and development of new sustainable, degradable, and chemically recyclable plastics with improved performance, providing alternative solutions to the growing global plastics crisis.

Each year, CCIs include more than 70 participating academic institutions, 60 non-academic partner institutions, 130 Senior Personnel, 90 Postdoctoral Associates, 250 Graduate Students, and 90 Undergraduate Students.

Engineering Research Centers - ENG

The FY 2024 Request is $86.09 million to support 19 NSF Engineering Research Centers (ERC), which advance clean energy and climate change mitigation, biotechnology, quantum technology, semiconductors and microelectronics, and other national priorities. The investment includes support for four Gen-4 ERCs, funded as part of the Class of 2024, that will conduct convergent engineering research to tackle high-impact challenges with the potential to benefit U.S. security, prosperity, health, and society. The Class of FY 2024 ERCs will implement strategies for effective team formation and engagement with stakeholder communities to maximize their impacts.

All NSF ERCs combine the intellectual curiosity of university research focused on discovery with real-world engineered systems and technology opportunities through partnerships with industry. Each

ERC has interacting foundational components that go beyond the research project, including engineering workforce development at all participant stages, a culture of diversity and inclusion where all participants gain mutual benefit, and value creation within an innovation ecosystem that will outlast the lifetime of the ERC.

Since the program began in 1985, products of ERC innovation include more than 2,600 inventions disclosures, over 2,300 patent applications filed, more than 900 patents awarded, and 1,381 licenses, as well as more than 240 spinoff companies. ERCs also have a successful track record for educating a technology-enabled workforce with hands-on, real-world experience. On average, NSF ERCs graduate over 130 Bachelor's, 123 Master's, and 150 Doctoral degree students each year. Over that time, they have also impacted, on average over 2,500 K-12 teachers and students. NSF ERCs are also effective at broadening participation from underrepresented groups. For example, across currently active ERCs, women comprise approximately 36 percent of those involved in center activities, in comparison to the national average of 24 percent across engineering. Also, the percentage of people from underrepresented groups participating is more than double that of engineering's national average.

Materials Centers - MPS

The FY 2024 Request level of $57.0 million is expected to support up to 19 Materials Research Science and Engineering Centers (MRSEC). The triennial MRSEC competition that began in June FY 2022 is expected to conclude in FY 2023. Funding in FY 2024 will continue support of 11 new centers established in FY 2020 and up to 8 new centers from the FY 2023 competition.

MRSECs function as hubs for solving complex grand-challenge materials problems requiring broad multidisciplinary expertise within the physical sciences and engineering to understand materials phenomena, exploit materials properties, and to create and discover new materials. Research in materials science is inherently interdisciplinary and the MRSEC program is a prime example of convergent research encompassing physics, chemistry, mathematics, biology, materials science, and engineering. Through collaborative efforts involving academics, industry, national laboratories experts, and international and educational partners, MRSECs advance materials research and education in the United States, and in many cases are international leaders. MRSECs have served as partners with more than 50 MSIs and develop new pathways for underrepresented groups, aiming to educate and train a diverse materials workforce across the U.S.

MRSECs have six major coordinated components: (1) interdisciplinary research groups, (2) education and outreach, (3) industrial and international outreach/partnerships, (4) diversity and broadening participation – serving as a major partner with Minority-Serving Institutions in MPS/DMR Partnerships in Research and Education in Materials (PREM) program, (5) the Materials Research Facilities Network—providing access to more than 1,250 state-of-the art equipment instrumentation to materials researchers across the Nation—and (6) the seed program, which enables MRSECs to rapidly react to and move into new high-risk and potentially transformative areas not yet fully explored.

Each year, MRSECs produce over 180 Ph.Ds. in STEM fields, mentor nearly 400 Research Experiences for Undergraduate students and 60 Research Experiences for Teachers participants, and impact over one million students and their parents through outreach activities such as summer camps, K-12 science curriculum development, K-12 in-school science demonstrations, development and deployment of science kits, and partnering with the Nation's top museums to create STEM-related exhibits that impact the public. Since 1994, the program has created approximately 180 startups and

annually produces about 60 awarded patents and 35 patent licensures. MRSECs engage and assist more than 500 other individuals from industry, national laboratories, and international partners per year in advancing fundamental materials research that can be translated into the marketplace.

Quantum Leap Challenge Institutes – MPS

The FY 2024 Request level of $20.0 million will support five Quantum Leap Challenge Institutes (QLCI). Each institute addresses one of the key areas of QIS research - sensing, computing, networking, quantum simulation, and potential applications in biology and bioengineering. Total award sizes for each institute are $25.0 million over five years. In FY 2024, NSF will continue the Expand QISE thrust begun in FY 2022, which focuses on enhancing the participation of academic institutions not currently participating in the national QISE initiative and promoting the inclusion of members of groups currently underrepresented in the field.

Quantum information science and engineering utilizes profound aspects of quantum physics such as superposition, interference, and entanglement to develop revolutionary approaches for information processing. Such approaches include quantum computation, quantum communication, quantum simulation and quantum sensing. These rapidly developing fields have been bolstered by recent discoveries and breakthroughs. However, several foundational and technological challenges must be overcome before the full potential of quantum information science and engineering can be realized. The QLCI's program goal is to support timely and bold research agendas aimed at making breakthroughs on one of these clearly identified and compelling challenges within a five-year period. QLCIs are expected to: engage an intellectually-diverse community in the pursuit of identified challenges; develop cohesive, collaborative and national-scale approaches to research in quantum information science and engineering; and enable the development of a well-trained workforce with strong cross-disciplinary skill sets needed for quantum information science and engineering.

The QLCI program, along with other NSF multidisciplinary centers related to quantum research and education, collectively address Section 302 of the 2018 National Quantum Initiative Act. In addition, as all of the institutes funded under the QLCI program address topics that have been identified by the NSTC Subcommittee on Quantum Information Science as being critical to the U.S. investment in QIS, the program exercises a key role in the NSF response to this need.

NSF Regional Innovation Engines – TIP

The FY 2024 Request level of $300.0 million will support up to 20 NSF Regional Innovation Engines (NSF Engines) in FY 2024. The NSF Engines program constitutes a bold new initiative that aims to create regional-scale innovation ecosystems throughout the United States and spur economic growth and job creation by bringing together the science and technology research enterprise and regional-level resources to address societal and economic challenges and promote long-term national competitiveness. NSF is providing funding to support activities focused on use-inspired research, entrepreneurship, and workforce development to nurture and accelerate regional industries. The NSF Engines program specifically emphasizes the meaningful engagement of the consumers of research outcomes in informing and shaping the research questions; prototyping and piloting research-based solutions (i.e., co- design and co-creation); and translating research results to practice, entrepreneurship, and direct economic growth.

In particular, the NSF Engines will aim to advance use-inspired, solutions-oriented research and innovation in a range of emerging technologies (e.g., advanced manufacturing, advanced wireless, AI,

biotechnology, QIS, semiconductors) as well as in a diverse set of regional and national challenges (e.g., climate change and the bioeconomy). They will bring together multiple disciplines, institutions, and sectors. They will balance technical and geographic (i.e., local and regional challenges, capabilities, and perspectives) innovation as well as individual, organizational, and geographic diversity; incentivize partnerships between NSF, other federal agencies, academia, industry, nonprofits, state, local, and tribal governments, civil society, and communities of practice; and serve as hubs for NSF's broader portfolios of investment in their respective areas of focus.

The bold nature of this effort is reflected in the program's goals, as described above; the nature and types of partnerships expected; the outputs that are being tracked and assessed (notably an emphasis on technology and workforce capabilities); the level of post-award oversight; the budgets of the NSF Engines, which are an order of magnitude greater than traditional NSF center-scale awards; and the duration of NSF funding for the NSF Engines, i.e., a ten-year award lifetime, paired with an intentional focus on longer-term sustainability from day one. Notably, the NSF Engines are funded at levels of up to $160 million over up to ten years.

Science and Technology Centers: Integrative Partnerships – multi-directorate

The FY 2024 Request level of $74.60 million will support at least 14 Science and Technology Centers (STC) and the administrative costs associated with program management and oversight. These include STCs from the FY 2016 and FY 2021 cohorts and new centers to be funded in FY 2023, which will replace the sunsetting cohort funded in FY 2013. Preliminary proposals for the Class of FY 2023 were received in February 2022. Currently, STC awards are for five years, with possible renewal for an additional five years, or ten years total. For the 2016 and 2021 cohorts, award sizes are approximately $5.0 million per year with ramp down in years nine and ten. Beginning with the 2023 cohort competition proposal requests may include budgets of up to $6.0 million per year.

The STC program advances interdisciplinary discovery and innovation in science and engineering through the integration of cutting-edge research, excellence in education, targeted knowledge transfer, and the development of a diverse workforce. The STC portfolio reflects NSF-supported disciplines; examples include: improving agricultural production via programmable plants based on digital biology; new technologies and solutions to limit the need for phosphorus usage in agricultural practice while reducing its harmful environmental impacts by enabling phosphorus recovery from the environment; advancing the understanding of Earth's climate; and realizing a new generation of optoelectronic materials and devices. Some STCs' research leads to the creation of new technologies that allow leaps in research capability. Recent examples include the development of a new generation of imaging capabilities and advances in particle accelerator technologies.

STCs conduct world-class research through partnerships among institutions of higher education, national laboratories, industry, other public or private entities, and via international collaborations. STCs strengthen the caliber of the Nation's STEM workforce through intellectually challenging research experiences for students, postdoctoral fellows, researchers, and educators. One of the goals of STCs is to increase involvement of traditionally underrepresented groups and institutions in science and engineering, which they achieve through dedicated mentoring and partnerships, most notably with MSIs and emerging research institutions. Additionally, STCs advance public scientific understanding through partnerships with K-12 and informal education communities. The knowledge transfer activities focus on engaging stakeholders with the intent of supporting innovation, providing information to policymakers, and disseminating knowledge across scientific disciplines. The STC

program uses a network of evaluators working with the centers to share information and lessons learned about the most effective way to measure progress. In FY 2022, NSF initiated a study by the Science and Technology Policy Institute to examine the contributions STCs make to science and society.

Spectrum Innovation Initiative: National Center for Wireless Spectrum Research (SII-Center) – MPS

The FY 2024 Request level of $17.0 million is to fund the continuing operations of the SII-Center program. The worldwide growth of wireless communication, navigation, and telemetry has provided immense societal benefits including mobile broadband data, Internet of Things (IoT), mobile healthcare, and intelligent transportation systems. These and other applications call for innovations that can circumvent the challenges of radio spectrum scarcity and interference, and foster the growth of ubiquitous, high speed, low latency connectivity. Commercial applications like the above must operate in harmony with scientific uses of spectrum (e.g., radio astronomy, Earth and atmospheric sciences, and polar research) and other nationally vital spectrum-dependent services (e.g., weather prediction). NSF continues to support wireless spectrum research and the scientific uses of the electromagnetic spectrum through multiple programs that enable fast, accurate, dynamic coordination and usage of the limited spectrum resource. These programs have created an opportune ground to build and create a large center-based ecosystem for spectrum research, which is the target of this SII-Center program. The goal of this program is to chart out a trajectory to ensure United States leadership in future wireless technologies, systems, and applications in science and engineering through the efficient use and sharing of the radio spectrum. A key expectation is establishing harmony between scientific uses of the electromagnetic spectrum and the forthcoming technological advances for highspeed, low latency, secure connectivity among pervasive devices, autonomous vehicles, and numerous other platforms. SII-Center will serve as a focal point for sustained research in the most challenging topics in spectrum. Research in these areas is expected to create advanced wireless technologies and systems that benefit society, of which 5G and future wireless broadband networks are an example. SII-Center is also expected to facilitate the education and development of an agile workforce needed to support emerging industries. These industries will rely heavily on wireless technologies and will require new advanced and automated spectrum management techniques. NSF's goal is to promote transformative use and management of the electromagnetic spectrum, resulting in profound benefits for science, engineering, industry, and other national interests.

NSF is working closely with the Federal Communications Commission and the National Telecommunications Information Administration to ensure that NSF SII investments in spectrum research and development are in alignment with national spectrum regulatory and policy objectives, principles, and strategies.[1]

[1] www.fcc.gov/document/fcc-federal-partners-sign-spectrum-innovation-cooperation-agreement

Estimates for Centers Participation in 2022

	Number of Participating Institutions[1]	Number of Partners[2]	Total FY 2022 NSF Support ($ in millions)	Total Leveraged Support ($ in millions)[3]	Number of Participants[4]
AI Research Institutes	121	224	$53.88	$16.00	N/A
Biology Integration Institutes	374	52	25.90	N/A	2,239
Centers for Analysis & Synthesis	21	29	1.50	N/A	134
Centers for Chemical Innovation	76	64	27.46	4.00	608
Engineering Research Centers	855	290	70.47	100.55	3,604
Materials Centers	149	146	53.27	23.00	3,000
Quantum Leap Challenge Insts	37	42	58.37	-	468
NSF Regional Innovation Engines	N/A	N/A	0.71	N/A	N/A
Science & Technology Centers	161	207	55.99	30.01	1,842
Spectrum Innovation Initiative Ctr	29	22	17.00	-	461

[1] All academic institutions participating in activities at the centers.

[2] The total number of non-academic participants, including industry, states, and other federal agencies at the centers.

[3] Funding for centers from sources other than NSF.

[4] The total number of people who use center facilities, not just persons directly support by NSF.

Centers Supported by NSF in 2022

Center	Institution	State
Artificial Intelligence Research Institutes		
Artificial Intelligence for Environmental Sciences (AI2ES)	U of Oklahoma	OK
Institute for Foundations of Machine Learning	U of Texas at Austin	TX
Institute for Student-AI Teaming	U of Colorado at Boulder	CO
Molecule Maker Lab Institute (MMLI): An AI Institute for Molecular Discovery, Synthetic Strategy, and Mfg.	U of Illinois Urbana-Champaign	IL
AI Research Institute for Fundamental Interactions	MIT	MA
AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups (AI-CARING)	Georgia Tech Research Corp.	GA
AI Institute for Learning-enabled Optimization at Scale (TILOS)	U of California-San Diego	CA
AI Institute for Advances in Optimization	Georgia Tech Research Corp.	GA
AI Institute for Intelligent CyberInfrastructure with Computational Learning in the Environment (ICICLE)	Ohio State University	OH
AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE)	Ohio State University	OH
AI Institute for Edge Computing Leveraging Next Generation Networks (Athena)	Duke University	NC
AI Institute in Dynamic Systems	University of Washington	WA
AI Institute for Engaged Learning	North Carolina State University	NC
AI Institute for Adult Learning and Online Education	Georgia Research Alliance	GA
Biology Integration Institutes		
Behavioral Plasticity Research Institute (BPRI)	Baylor College of Medicine	TX
Emergent Ecosystem Responses through Genes-to-Systems Institute (EMERGE)	Ohio State University	OH
Advancing Spectral biology in Changing Environments to understand Diversity (ASCEND)	University of Minnesota-Twin Cities	MN
Genomics and Eco-evolution of Multi-scale Symbioses Institute (GEMS)	University of Illinois at Urbana-Champaign	IL
Host-Virus Evolutionary Dynamics Institute (HVEDI)	University of Arkansas	AR
Mechanisms of Cellular Evolution	Arizona State University	AZ
New Roots for Restoration	Donald Danforth Plant Sci. Ctr.	MO
Uncovering mechanisms of amphibian resilience to global change from molecules to landscapes	University of Pittsburgh	PA
Emergent Mechanisms in Biology of Robustness, Integrations & Organization (EMBRIO)	Purdue University	IN
Regional OneHealth Aerobiome Discovery Network	Colorado State University	CO
Institute for Symbiotic Interactions, Teaching, and Education in the Face of a Changing Climate (INSITE)	U of California – Merced	CA
Life without water: protecting macromolecules, cells, and organisms during desiccation and rehydration across kingdoms of life	Carnegie Institution of Washington	WA

Discovering the mechanisms and evolution of aging differences between females and males (IISAGE)	University of Alabama at Birmingham	AL
Predicting the global host-virus network from molecular foundations	Georgetown University	DC
Centers for Analysis and Synthesis[2]		
Socio-Environmental Synthesis Center (SESYNC)	U of Maryland	MD
Environmental Data Science Innovation and Inclusion Lab (ESIIL)	U of Colorado at Boulder	CO
Centers for Chemical Innovation (Phase II awards only)[3]		
Center for Chemical Evolution (CCE)	Georgia Institute of Tech	GA
NSF Center for Sustainable Nanotechnology (CSN)	U of Wisconsin	WI
NSF Center for Sustainable Polymers (CSP)	U of Minnesota	MN
NSF Center for Aerosol Impacts on the Chemistry of the Environment (CAICE)	U of California-San Diego	CA
NSF Center for Selective C-H Functionalization (CCHF)	Emory	GA
NSF Center for Genomically Encoded Materials (CGEM)	U of California-Berkeley	CA
NSF Center for Synthetic Organic Electrochemistry (CSOE)	U of Utah	UT
NSF Center for the Chemistry of Molecularly Optimized Networks (MONET)	Duke University	NC
The Center for Computer Aided Synthesis (C-CAS)	U of Notre Dame	IN
Engineering Research Centers		
Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)	North Carolina State	NC
Bio-mediated and Bio-inspired Geotechnics (CBBG)	Arizona State	AZ
Engineering Research Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR)	Purdue	IN
Engineering Research Center for Precise Advanced Technologies and Health Systems for Underserved Populations (PATHS-UP)	Texas A&M	TX
Nanomanufacturing Systems for Mobile Computing and Mobile Energy Technologies (NASCENT)	U of Texas	TX
Nanosystems Engineering Research Center for Directed Multiscale Assembly of Cellular Metamaterials with Nanoscale Precision (CELL-MET)	Boston College	MA
Nanotechnology Enabled-Water Treatment System	Rice University	TX
NSF Engineering Research Center for Cell Manufacturing Technologies (CMaT)	Georgia Institute of Tech	GA
Optimization for Electro-thermal Systems (POETS)	U of Illinois	IL
NSF Engineering Center for Quantum Networks (CQN)	U of Arizona	AZ
NSF Engineering Research Center for the Internet of Things for Precision Agriculture (IoT4Ag)	U of Pennsylvania	PA

[2] NIMBioS and SESYNC are operating on no-cost extensions. No funds were obligated for the centers in FY 2022.
[3] Smaller, developmental Phase I awards do not meet the criteria as formal NSF Centers and so are not captured here.

NSF Engineering Research Center for Advancing Sustainability Through Powered Infrastructure for Roadway Electrification (ASPIRE)	Utah State University	UT
NSF Engineering Research Center for Advanced Technologies For Preservation of Biological Systems (ATP-Bio)	U of Minnesota	MN
NSF Engineering Research Center for Precision Microbiome Engineering (PreMiEr)	Duke University	NC
NSF Engineering Research Center for Smart Streetscapes (CS3)	Columbia University	NY
NSF Engineering Research Center for Advancing Sustainable and Distributed Fertilizer Production (CASFER)	Texas Tech University	TX
NSF Engineering Research Center for Hybrid Autonomous Manufacturing Moving from Evolution to Revolution (ERC-HAMMER)	Ohio State University	OH
Materials Centers		
Brandeis Bioinspired Soft Materials Center	Brandeis	MA
Center for Complex and Active Materials	U of California-Irvine	CA
Center for Dynamics and Control of Materials	U of Texas at Austin	TX
Center for Emergent Materials	Ohio State University	OH
Center for Hybrid, Active and Responsive Materials	U of Delaware	DE
Center for Multifunctional Materials	Northwestern	IL
Center for Nanoscale Science	Pennsylvania State	PA
Center for Polarization and Spin Phenomena in Nanoferroic Structures	U of Nebraska	NE
Chicago Materials Research Centers	U of Chicago	IL
Columbia Center for Precision Assembly of Superstratic and Superatomic Solids	Columbia	NY
Cornell Center for Materials Research	Cornell	NY
Harvard Materials Research Center	Harvard	MA
Illinois Materials Research Center	U of Illinois at U/C	IL
Laboratory for Research on the Structure of Matter	U of Pennsylvania	PA
Materials Research Science and Engineering Ctr at UCSB	U of California-Santa Barbara	CA
Materials Research Science and Engineering Center	U of California-San Diego	CA
Materials Research Science and Engineering Center	U of Minnesota	MN
MIT Center for Materials Science and Engineering	Massachusetts Institute of Tech	MA
NYU Materials Research Science and Engineering Center	New York U	NY
Princeton Center for Complex Materials	Princeton	NJ
Soft Materials Research Center	U of Colorado	CO
UW Molecular Engineering Materials Center	U of Washington	WA
Wisconsin Materials Research Center	U of Wisconsin	WI

Quantum Leap Challenge Institutes		
Enhanced Sensing and Distribution Using Correlated Quantum States	U of Colorado Boulder	CO
Hybrid Quantum Architectures and Networks	U of Illinois-Urbana Champaign	IL
Present and Future Quantum Computing	U of California-Berkeley	CA
Quantum Sensing in Biophysics and Bioengineering	U of Chicago	IL
Robust Quantum Simulation	U of Maryland-College Park	MD
Science and Technology Centers		
BEACON: An NSF Ctr. for the Study of Evolution in Action	Michigan State	MI
Biology with X-Ray Free Electron Lasers	SUNY Buffalo	NY
Center for Brains, Minds, and Machines: The Science and the Technology of Intelligence	Massachusetts Institute of Tech	MA
Center for Bright Beams	Cornell	NY
Center for Cellular Construction	U of California-San Francisco	CA
Center for Chemical Currencies of a Microbial Planet	Woods Hole Ocean. Inst	MA
Center for Dark Energy Biosphere Investigations	U of Southern California	CA
Center for Emergent Behaviors of Integrated Cellular Systems	Massachusetts Institute of Tech	MA
Center for Energy Efficient Electronics Science	U of California-Berkeley	CA
Center for Engineering MechanoBiology	U of Pennsylvania	PA
Center for Integrated Quantum Materials	Harvard	MA
Center for Integration of Modern Optoelectronic Materials on Demand	U of Washington	WA
Center for Learning the Earth with Artificial Intelligence and Physics	Columbia U	NY
Center for OLDest Ice Exploration	Oregon State U	OR
Center for Research On Programmable Plant Systems	Cornell	NY
Center for Science of Information	Purdue	IN
S&T Center on Real-Time Functional Imaging	University of Colorado	CO
S&T Technologies for Phosphorus Sustainability Center	North Carolina State U	NC
Spectrum Innovation Initiative		
Spectrum X – An NSF Spectrum Innovation Center	University of Notre Dame	IN

SECURE AND TRUSTWORTHY CYBERSPACE (SaTC)

Secure and Trustworthy Cyberspace Funding[1]

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request
CISE	$73.53	$70.00	$5.00	$75.00	$75.00
EDU	63.00	74.00	-	74.00	74.00
ENG	3.25	3.25	-	3.25	3.25
MPS	1.27	1.25	-	1.25	1.25
SBE	4.00	4.00	-	4.00	4.00
Total	**$145.05**	**$152.50**	**$5.00**	**$157.50**	**$157.50**

[1] Funding displayed may have overlap with other topics and programs.

Overview

In today's increasingly networked, distributed, and asynchronous world, society is deeply reliant on digital infrastructure—and protecting the security of that infrastructure (also known as cybersecurity) involves hardware, software, networks, data, people, and integration with the physical world. Recent events have exposed the dual nature of cyberspace: while it is an unprecedented source of innovation, efficiency, and economic growth, it also brings the potential for attacks on enterprises, loss of privacy, and even erosion of trust in democratic institutions. Indeed, key components of the digital infrastructure were not designed to operate in a hostile environment with highly capable adversaries. Achieving a truly secure and trustworthy cyberspace, therefore, requires addressing not only scientific and engineering problems involving many components of a complex system, but also issues that arise from human behaviors and choices, and societal and cultural factors. Examining the fundamental principles of security and privacy as an inter- and multi-disciplinary subject constitutes a promising approach to develop better ways to design, build, and operate cyber systems; to protect existing and future infrastructure; and to motivate and educate individuals about cybersecurity and privacy. Achieving these goals not only requires expertise in computer and information science; engineering; mathematics; statistics; the social, behavioral, and economic sciences; laws, policies, and regulations; and education research, but also the translation of new concepts and technologies into practice.

The SaTC program is a multi-year investment area that began in FY 2012 and continuously evolves to address new cybersecurity threats. SaTC is aligned with the 2019 *Federal Cybersecurity Research and Development Strategic Plan,*[1] which was developed pursuant to the Cybersecurity Enhancement Act of 2014 (P.L. 113-274) and will be aligned with the forthcoming 2023 *Federal Cybersecurity Research and Development Strategic Plan* which is scheduled for release late in 2023. Outcomes from SaTC include an organized scientific body of knowledge that informs the theory and practice of cybersecurity and privacy, and an improved understanding of the causes and mitigations of current and potential threats, as well as possible harms to individuals and society.

SaTC contributes to the development of foundational, preventative, and countermeasure techniques

[1] www.nitrd.gov/pubs/Federal-Cybersecurity-RD-Strategic-Plan-2019.pdf

leveraging sound mathematical and scientific foundations, principled design methodologies, and socio-technical approaches that consider people, social, organizational, economic, and technical factors, as well as design metrics and measurement techniques for evaluating the efficacy or effectiveness of these approaches. In the space of training and education, SaTC supports education research that leads to the development of new instructional approaches and materials, degree programs, and educational pathways, for example from the K-12 and undergraduate sector into the cybersecurity workforce. Ultimately, through SaTC, NSF funds a broad and deep inter- and multi-disciplinary research and education portfolio spanning cybersecurity and privacy, whose results underlie methods for securing critical cyber and cyber-physical infrastructure. Furthermore, NSF expects to produce an innovation ecosystem that ensures (a) new and existing technologies are secure from both current, emerging, and potential future threats as technologies evolve, and (b) information about individuals and groups is protected from violations of privacy despite new attack surfaces that these technologies may present. Additionally, SaTC significantly invests in cybersecurity education and workforce development activities to address the national cybersecurity workforce shortage through awards to meritorious proposals focusing on cyber security education. NSF's support in this area will lead to the development of a robust American workforce and citizenry with an understanding of broad cybersecurity and privacy issues. As the goals of SaTC contribute to national security and maintaining the U.S. leadership in cybersecurity and privacy R&D, NSF plans to continue investments in this area for the foreseeable future.

Goals

1. *Fundamental Research*: Develop the scientific theory, methodologies, and tools necessary for building trustworthy and usably secure systems and appropriate privacy safeguards that account for the role of people behavior and decision making.
2. *Accelerating Translation to Practice (TTP)*: Translate promising fundamental research results to practice.
3. *Education and Preparation of Cybersecurity and Privacy Researchers and Professionals*: Increase the number of qualified American students who pursue degrees in cybersecurity and privacy and enhance the capacity of institutions of higher education to produce professionals in these fields to meet the needs of our increasingly digital society. This goal includes NSF's investment in the CyberCorps®: Scholarship for Service (SFS) program.

FY 2024 Investments

<u>Fundamental Research</u>

- NSF is undertaking a major revision of the SaTC program in 2023 that will lead to a new solicitation in FY 2024. The new solicitation is intended to significantly broaden the scope of the SaTC program by including emerging scientific cybersecurity and privacy research areas that have been identified in conjunction with key stakeholders over the past few years. Through this revised solicitation, NSF will continue to fund innovative projects that advance the science and engineering of cybersecurity and privacy, with emphases on: 5G and Beyond wireless networks; integrity of information especially in the context of images, audio, and video; security of the open source ecosystem; learning enabled systems such as autonomous vehicles and robots; quantum computing for security, including post-quantum cryptography; developing new architectures, systems, and technologies for protecting cyberspace from new and increasingly sophisticated attacks including adversarial machine learning; smart infrastructure including advanced

manufacturing and precision agriculture; countering new threats in virtual and augmented reality (AR/VR); securing the next generation of hardware and semiconductors from fabrication to design to operation; and ensuring safety and security in biometric authentication while also preserving privacy.

- NSF will continue its efforts to grow the cybersecurity and privacy research community to include more researchers who cross the boundaries between computer and information science; engineering; mathematics; statistics; the social, behavioral, and economic sciences; and education research. In support of this specific aim, NSF will hold a range of workshops on cutting-edge topics. For example, NSF plans to develop a series of workshops and summer schools that will explore the role of cybersecurity and privacy in virtual, augmented, and extreme reality, biotechnology, post-Moore computing hardware, architectures, and systems, and advanced wireless networks beyond 5G.
- In FY 2022, NSF was part of the Open-Source Software Security Initiative (OS3I) Working Group tasked by the National Cyber Director to engage public and private stakeholders to learn about risks and opportunities to improve the security of the open-source software ecosystem. NSF convened a workshop in the summer of 2022 with diverse representatives from the open-source software community, which resulted in a publicly released report[2] of recommendations for the federal government. This activity directly aligns with the relatively new NSF Pathways to enable Open-Source Ecosystems (POSE) program noted below.
- In FY 2022, under the leadership of the White House Office of Science and Technology Policy (OSTP), NSF and the Office of the Director of National Intelligence led an interagency working group that developed a report that lays out a "Roadmap for Researchers on Priorities for Information Integrity Research and Development[3]", published in December 2022. In alignment with this report, NSF released a Dear Colleague Letter (DCL)[4] encouraging the research community to submit novel and high impact proposals to the SaTC program that advance knowledge on the integrity of information. In FY2024 NSF will continue to encourage meritorious proposals on the priorities identified in the report.

Accelerating Translation to Practice (TTP)

- Through the SaTC program, NSF will continue its focus on translating research results that are ready for experimental deployment, early adoption, commercial innovation, and/or implementation through support of TTP-designated projects. These projects must demonstrate how technology from prior successful research results will be deployed into an organization, system, or community. The outcome of a TTP-designated project should be demonstrable advancement in the technology's readiness, robustness, validation, or functionality.
- NSF will also continue support for focused efforts to mature technologies emerging from fundamental research. For example, in FY 2023, NSF is continuing the Privacy-Enhancing Technologies (PETs) Prize Challenges in collaboration with OSTP, NIST, and the Government of the United Kingdom, to mature PETs to the point of demonstrating their viability in the context of specific use cases.
- NSF will also continue to support research infrastructure, including testbeds, in cybersecurity and privacy in conjunction with the NSF Directorate for Computer and Information Science and

[2] Keromytis, Angelos, D., "Recommendations from the Workshop on Open-Source Software Security Initiative," September 2022, OSSI-Final-Report.pdf.

[3] www.whitehouse.gov/wp-content/uploads/2022/12/Roadmap-Information-Integrity-RD-2022.pdf

[4] www.nsf.gov/pubs/2022/nsf22050/nsf22050.jsp

Engineering (CISE) Community Research Infrastructure program and the TIP-led POSE program.

Education and Preparation of Cybersecurity Researchers and Professionals

- In alignment with the 2019 *Federal Cybersecurity Research and Development Strategic Plan*, and the forthcoming 2023 *Federal Cybersecurity Research and Development Strategic Plan*, NSF will continue its focus on cybersecurity education in FY 2024 with the aims of (a) building and sustaining an unrivaled cybersecurity workforce; (b) promoting the development and maintenance of inclusive learning settings to improve diversity in cybersecurity; and (c) raising cybersecurity awareness across the general population.
- In FY 2024, NSF will fund programs in the K-12 and higher education sectors that strengthen pathways for the national cybersecurity workforce including support for innovation at the K-12 level, community colleges, and four-year universities. This funding is intended to further expand or initiate new cybersecurity education programs, which improve education delivery methods for K-12 students, teachers, counselors, and post-secondary institutions and encourage students to pursue cybersecurity careers.
- CyberCorps®: SFS will address the nation's critical shortage of cybersecurity educators and researchers by allowing up to 10 percent of SFS scholars to fulfil their government service obligation through service as faculty members engaged in undergraduate- and graduate-level education in cybersecurity. SFS will also continue to support collaborative efforts among the AI, cybersecurity, and education research communities to foster a robust workforce with integrated AI and cybersecurity competencies; and explore new collaborations at the intersection of cybersecurity and privacy, and other priority areas such as quantum computing and aerospace as authorized by the CHIPS and Science Act.
- CyberCorps®: SFS will seek to increase investments in K-12 as well as post-secondary education with the aim of growing interest in cybersecurity careers and their intersection with other key areas of national interest such as data science and AI. Such investments will promote learning of foundational cybersecurity principles and safe online behavior; develop curriculum materials and improve teaching methods to help K-12 teachers and college professors integrate cybersecurity and privacy into formal and informal learning settings; develop new knowledge on how people learn the concepts, practices, and ways of thinking in cybersecurity; and promote teacher recruitment in the field of cybersecurity.
- With the aim of building inclusive environments and increasing the representation of students of all races, ethnicities, and genders earning cybersecurity graduate degrees. CyberCorps®: SFS will continue to make investments to (a) understand barriers to diversity, equity, and inclusion at SFS institutions; (b) implement best practices to address such barriers; and (c) empower SFS institutions to build bridge programs that connect graduate degree-seeking individuals who are members of populations currently underrepresented in computing to advanced degrees in cybersecurity

SPECTRUM INNOVATION INITIATIVE (SII)

SII Funding
(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate	FY 2024 Request
$17.00	**$17.00**	**$17.00**

Overview

The electromagnetic spectrum and its management play a crucial role in many ways for the United States, including scientific investigation of the world around us, public safety and security, and the provision of a tremendous range of communication devices. The SII is a multidisciplinary, cross-Directorate, NSF-wide program to promote dynamic and agile electromagnetic spectrum utilization, while ensuring innovation and security for all users: both active spectrum applications such as those in advanced wireless and spectrum for passive scientific purposes such as radio astronomy and geospace sciences. The SII promotes United States leadership through basic research, infrastructure development, new collaborations, public outreach, education, and workforce development.

Goals

NSF's goal is to promote transformative use and management of the electromagnetic spectrum, resulting in profound benefits for science and engineering, industry, and other national interests. As demands for spectrum availability have increased, the need to use this limited natural resource more efficiently and robustly to meet multiple goals has also increased. Increasing demand for spectrum from applications such as 5G-and-beyond networks, national defense systems, and cutting-edge tools and facilities utilized by scientific research for atmospheric sensing, astronomy, and other purposes are major sources of demand for spectrum availability. Innovation is required to solve the challenge of achieving the most efficient spectrum utilization for these and other purposes. While NSF has supported successful spectrum research activities for many years, the SII represents an increased, coherent, and sustained commitment on a larger and more interdisciplinary scale. This initiative will result in increased industry, research, and societal capabilities through more efficient use of the electromagnetic spectrum, and development of a technologically sophisticated workforce. Enhancing efficient spectrum utilization and access is vital to the national interest, including the scientific enterprise, national defense, and emerging industries. NSF is working closely with the Federal Communications Commission and the National Telecommunications and Information Administration to ensure that NSF SII investments in spectrum research and development are in alignment with national spectrum regulatory and policy objectives, principles, and strategies[1].

The primary goals of the SII include the following:

1. Develop the concept and infrastructure for National Radio Dynamic Zones (NRDZ), which will be used for testing of next-generation, advanced dynamic spectrum utilization techniques within pilot test beds in unique geographic locations to minimize regulatory hurdles that slow innovation. The goal is improved spectrum efficiency/effectiveness through secure/autonomous spectrum decision making.

[1] www.fcc.gov/document/fcc-federal-partners-sign-spectrum-innovation-cooperation-agreement

2. Establish and sustain an interdisciplinary National Center for Wireless Spectrum Research (SII-Center) that will catalyze partnerships between government, industry, and academia, and bring teams of scientists, engineers, computer scientists, and social scientists together to innovate. The goal of the SII-Center is to develop new solutions that enable more efficient use of the electromagnetic spectrum.
3. Integrate NRDZ and the SII-Center with the frontier research currently being conducted through other NSF programs and facilities. Those programs include, for example, the NSF-industry partnership in Platforms for Advanced Wireless Research (PAWR), the Spectrum and Wireless Innovation enabled by Future Technologies (SWIFT) program, and NSF facilities performing cutting edge scientific research which require access to the electromagnetic spectrum such as the Green Bank Observatory, the National Radio Astronomy Observatory, and the National Center for Atmospheric Research.
4. Promote opportunities and develop the workforce needed, as a key national resource, to research and implement the dynamic and agile spectrum utilization techniques that will secure access to the spectrum for receive-only systems and enable the broadband applications of tomorrow.
5. Develop increased public awareness of the scarcity of the electromagnetic spectrum resource, and the challenges associated with its scarcity and its efficient use.

FY 2024 Investments

Investments in FY 2024 include the following:

National Radio Dynamic Zones ($9.0 million)
This investment will continue work on spectrum sharing solutions, site studies and application studies for National Radio Dynamic Zones towards enhancement of active electromagnetic spectrum management efforts at NSF's major research facilities and platforms. The investment will also initiate work to understand social, behavioral, and economic issues that affect the deployment of radio dynamic zones.

National Center for Wireless Spectrum Research ($5.0 million)
This investment will sustain activities of the interdisciplinary SII-Center program, which brings together diverse groups of researchers to develop, innovate, and sustain new solutions that enable more efficient use of the electromagnetic spectrum.

Integration Activities ($2.0 million)
This investment will continue to integrate ongoing and increasing NSF activities, including SWIFT research, partnerships with EPSCoR to explore active radio frequency interference cancellation and build workforce capacity, and the support of national and international spectrum regulatory efforts, such as NSF's management of polar programs.

Workforce Development and Public Outreach ($1.0 million)
To promote national leadership in spectrum innovation and enhance opportunities on both national and local levels, including for underserved communities, the investment in workforce development will include fellowships associated with the above efforts and research funded through SWIFT, PAWR, and the SII-Center, as well as Research Experiences for Undergraduates. The public outreach efforts will include supplements to existing awards that enable enhanced public awareness of the electromagnetic spectrum and the challenges associated with its scarcity and its efficient use.

SELECTED CROSSCUTTING PROGRAMS

Many investments at NSF draw on interdisciplinary teams from across the Foundation. Other parts of this chapter, NSF-Wide Investments, provide narratives for selected NSF-wide investments. Additional cross-cutting programs are presented in the narrative below.

ADVANCE

In FY 2024, $22.33 million is requested for the ADVANCE program to encourage institutions of higher education and the broader science, technology, engineering, and mathematics (STEM) community, including professional societies and other STEM-related not-for-profit organizations, to address various aspects of STEM academic culture and institutional structure to enhance gender equity for faculty and academic administrators. As such, ADVANCE is an integral part of NSF's multifaceted strategy to broaden participation in the STEM workforce and supports the critical role of the Foundation in improving the recruitment, retention, success, and advancement of women and girls in academic science and engineering. Further, ADVANCE contributes important research on successfully supporting organizational change to address systemic barriers to equity for all faculty. EDU stewards funding for ADVANCE to support projects in all areas of NSF STEM disciplines.

Faculty Early Career Development (CAREER)

The CAREER program offers NSF's most prestigious awards in support of early-career faculty and is designed to provide stable support at a sufficient level and duration to enable awardees to develop careers not only as outstanding researchers but also as educators demonstrating commitment to teaching, learning, and dissemination of knowledge. The FY 2024 Request provides $380.10 million for the CAREER program, funding approximately 680 new CAREER awards, which support exceptionally promising college and university junior faculty who are committed to the integration of research and education and who are most likely to become the leaders in their fields.

Industry-University Cooperative Research Centers (IUCRC)

The Industry–University Cooperative Research Centers program accelerates the impact of basic research through close relationships between industry innovators, world-class academic teams, and government leaders. IUCRCs are designed to help corporate partners and government agencies connect directly and efficiently with university researchers to achieve three primary objectives. 1) Conduct high-impact research to meet shared industrial needs in companies of all sizes; 2) Enhance U.S. global leadership in driving innovative technology development; and 3) Identify, mentor, and develop a diverse high-tech, exceptionally skilled workforce. NSF created the IUCRC program in 1973 to foster long-term partnerships among industry, academe, and government. These partnerships support research programs of mutual interest, contribute to the nation's research infrastructure base, promote workforce development, and facilitate technology transfer. Every year, more than 2,000 students engage in industrially relevant research at Centers nationwide, giving them on the job training for a career in the private sector. About 30 percent of these student researchers are hired by the member companies. The FY 2024 Request provides $21.86 million for the IUCRC program.

Long-Term Ecological Research (LTER)

The FY 2024 Request provides $32.93 million for LTER. LTER supports fundamental research that requires data collection over long time periods, to unravel the principles and processes of ecological science, which frequently involves long-lived species, legacy influences, and rare events. This program supports a loosely coordinated network of 28 field sites that focus on: (1) understanding ecological phenomena that occur over long temporal and broad spatial scales; (2) creating a legacy of well-designed, long-term ecological experiments; (3) conducting major syntheses and theoretical efforts; and (4) providing information to identify and to address environmental challenges. LTER projects represent a diversity of habitats in continental North America, the Caribbean, Pacific Ocean, Arctic, and the Antarctic; including coral reefs, arid grasslands, estuaries, lakes, prairies, forests, alpine and Arctic tundra, urban areas, and agroecosystems. The support for LTER in FY 2023 will be used to sustain site-specific research activities examining ecological and evolutionary dynamics in natural populations, communities, and ecosystems, some of which have been studied for over 40 years and conducting syntheses of long-term data using contemporary modeling methods

The National Ecological Observatory Network (NEON) infrastructure is co-located at nine LTER sites. NEON is a continental-scale infrastructure facility providing standardized physical and data resources to researchers and educators. LTER is a network of long-term research projects aimed at understanding ecological processes in a wide range of ecosystems. Ongoing research at LTER sites may take advantage of data generated using NEON infrastructure. In addition, the co-location of NEON infrastructure at some LTER sites will stimulate new research that builds on the long history of LTER research by enhancing the ability to extend site-based knowledge to regional and continental scales. For more information on NEON, see the NEON narrative in the Major Facilities chapter.

National Nanotechnology Coordinated Infrastructure (NNCI)

In FY 2024, $15.46 million is requested for the NNCI sites. This represents part of NSF's contribution to the National Nanotechnology Initiative (NNI), which is described in greater detail in the NNI section of NSF-Wide Investments chapter.

NSF Innovation Corps (I-Corps™)

In FY 2024, $50.0 million is requested for NSF Innovation Corps. The I-Corps™ program connects NSF-funded science and engineering research with the technological, entrepreneurial, and business communities, fostering a national innovation ecosystem that links scientific discovery with technology development, societal needs, and economic opportunities. The goal of the I-Corps™ program, created by NSF in 2011, is to reduce the time and risk associated with translating promising ideas and technologies from the laboratory to the marketplace. The program is designed to support the commercialization of deep technologies, or those revolving around fundamental discoveries in science and engineering. The I-Corps™ program addresses the skill and knowledge gap associated with the transformation of fundamental research into deep technology ventures. Its curriculum consists of experiential learning for customer and industry discovery, coupled with first-hand investigation of industrial processes, allowing teams to quickly assess the translational potential of inventions.

Research Experiences for Undergraduates (REU)

In FY 2024, $84.80 million is requested for the REU Sites and Supplements program. NSF's ongoing support for REU reflects the importance of undergraduate research experiences in building students' interest and competence in STEM disciplines. REU grants involve students at all stages of undergraduate education. REU Supplements allow students to join research projects that are supported by NSF research grants. REU Sites support cohorts of students to conduct research within STEM disciplines or on topics that cut across disciplines. Most of the students in an REU Site come from outside the host institution. This feature enables the program to involve students in research who might not otherwise have the opportunity, particularly students from institutions where faculty research activities are limited. The REU program encourages partnerships between community colleges and baccalaureate degree-granting institutions to provide research opportunities for community college STEM students and faculty. NSF's REU Sites and Supplements programs fall within the Improving Undergraduate STEM Education framework as affiliated programs, with budget and award decisions remaining within individual directorates.

Research in Undergraduate Institutions (RUI)

The FY 2024 Request for NSF's RUI program totals $35.49 million. The RUI activity seeks to support high quality research by faculty members of predominantly undergraduate institutions, strengthen the research environment in academic departments that are primarily oriented toward undergraduate instruction, and promote the integration of research and education of undergraduate students. RUI proposals are accepted in all fields of science and engineering supported by NSF, including research on learning and education.

NATIONAL SCIENCE FOUNDATION
SELECTED CROSSCUTTING PROGRAMS
FY 2024 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

Selected Crosscutting Programs		FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Estimate Base Amount	Change over FY 2023 Estimate Base Percent
	R&RA	-	-	-	-	-	-	N/A
ADVANCE	EDU	18.50	19.00	2.00	21.00	22.33	3.33	17.5%
	Total, NSF	**$18.50**	**$19.00**	**-**	**$21.00**	**$22.33**	**$3.33**	**17.5%**
	R&RA	403.42	408.47	-	408.47	365.10	-43.37	-10.6%
Faculty Early Career Development - CAREER[1]	EDU[1]	-	20.00	-	20.00	15.00	-5.00	-25.0%
	Total, NSF	**$403.42**	**$428.47**	**-**	**$428.47**	**$380.10**	**-$48.37**	**-11.3%**
	R&RA	22.73	22.20	-	22.20	21.86	-0.34	-1.5%
Industry-University Cooperative Res. Ctrs. - I/UCRC	EDU	-	-		-	-	-	N/A
	Total, NSF	**$22.73**	**$22.20**	**-**	**$22.20**	**$21.86**	**-$0.34**	**-1.5%**
	R&RA	30.34	30.81	-	30.81	32.93	2.12	6.9%
Long-Term Ecological Research Sites - LTERs	EDU	-	-	-	-	-	-	N/A
	Total, NSF	**$30.34**	**$30.81**	**-**	**$30.81**	**$32.93**	**$2.12**	**6.9%**
	R&RA	15.65	15.46	-	15.46	15.46	-	-
Nat'l Nanotechnology Coordinated Infrastructure - NNCI	EDU	-	-	-	-	-	-	N/A
	Total, NSF	**$15.65**	**$15.46**	**-**	**$15.46**	**$15.46**	**-**	**-**
	R&RA	39.93	50.00	-	50.00	50.00	-	-
NSF Innovation Corps - I-Corps™	EDU	-	-	-	-	-	-	N/A
	Total, NSF	**$39.93**	**$50.00**	**-**	**$50.00**	**$50.00**	**-**	**-**
	R&RA	60.41	62.08	-	62.08	66.82	4.74	7.6%
Research Experiences for Undergraduates - REU - Sites	EDU	-	-	-	-	-	-	N/A
	Total, NSF	**$60.41**	**$62.08**	**-**	**$62.08**	**$66.82**	**$4.74**	**7.6%**
	R&RA	20.17	17.82	-	17.82	17.98	0.16	0.9%
Research Experiences for Undergraduates - REU - Supps	EDU	-	-	-	-	-	-	N/A
	Total, NSF	**$20.17**	**$17.82**	**-**	**$17.82**	**$17.98**	**$0.16**	**0.9%**
	R&RA	37.94	31.99	-	31.99	35.49	3.50	10.9%
Research at Undergraduate Institutions - RUI	EDU	-	-	-	-	-	-	N/A
	Total, NSF	**$37.94**	**$31.99**	**-**	**$31.99**	**$35.49**	**$3.50**	**10.9%**

[1] EDU did not budget for CAREER funding in prior years.

IMPROVING UNDERGRADUATE STEM EDUCATION (IUSE)

Improving Undergraduate STEM Education Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental CHIPS + Science	FY 2023 Estimate Total	FY 2024 Request
BIO	$2.12	$1.50	-	$1.50	$5.00
CISE	0.57	3.00	-	3.00	3.00
EDU	93.50	93.50	32.10	125.60	93.50
ENG	-	5.00	-	5.00	6.65
Total	**$96.20**	**$103.00**	**$32.10**	**$135.10**	**$108.15**

Overview

High-quality undergraduate STEM education is essential for preparing the diverse, domestic STEM workforce needed to sustain U.S. leadership in innovation.[1,2] It is critical for producing STEM-knowledgeable and proficient workers who can use STEM skills in business, industry, and other sectors as well as a STEM-literate public that understands and benefits from STEM.[3] Furthermore, to respond to the shifting demands of convergence, demographic and societal changes, workforce adaptations, and technological advancements, the IUSE program aims to ensure that every student experiences high-quality learning opportunities and exceptional teaching in their STEM courses.[4]

To achieve this goal, the NSF-wide IUSE initiative invests in investigators and research and development projects that aim to improve undergraduate STEM education, ranging from individual STEM classrooms to nationwide STEM systemic efforts. Further, IUSE encourages proposal submissions focusing on innovative undergraduate STEM education that prepare the STEM workforce in interdisciplinary areas, such as computational and data-enabled science and engineering. It also solicits proposals in emerging fields, such as AI, Quantum Information Science (QIS), biotechnology, and critical industries, such as semiconductors and microelectronics. All IUSE projects must include assessment components and also must contribute new or expand knowledge about effective teaching and learning practices in undergraduate STEM education that can spur future innovations.

IUSE is one of EDU's core STEM education programs, soliciting for novel, creative, and transformative

[1] National Science Board (2018). Our Nation's Future Competitiveness Relies on Building a STEM-Capable U. S. Workforce. Retrieved from: www.nsf.gov/nsb/sei/companion-brief/NSB-2018-7.pdf

[2] Hulten, C. (2017). The Importance of Education and Skill Development for Economic Growth in the Information Era. In Education, Skills, and Technical Change: Implications for Future US GDP Growth. University of Chicago Press. Retrieved from: www.nber.org/chapters/c13937

[3] National Academies of Sciences, Engineering, and Medicine. (2016). Science literacy: Concepts, contexts, and consequences. National Academies Press. Retrieved from: www.nap.edu/catalog/23595/science-literacy-concepts-contexts-and-consequences

[4] National Academies of Sciences, Engineering, and Medicine. 2022. *Imagining the Future of Undergraduate STEM Education: Proceedings of a Virtual Symposium*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26314.

projects that have immense potential of producing new or expanded knowledge to improve STEM education for undergraduate students at both two- and four-year institutions, including Minority Serving Institutions (MSIs) and broad access institutions. In addition to supporting projects that have specific relevance to any NSF-supported discipline, it also funds projects that span all STEM disciplines. Examples of such cross-cutting efforts include incorporating active learning, institutional and community transformation, increasing access to undergraduate research experiences, and developing courses and instructional materials using emerging technologies (e.g. AI, augmented and virtual reality, etc.). This flexibility enables IUSE to respond rapidly to emerging STEM areas and Administration priorities. For example, in FY 2023, IUSE contributed to the Future of Semiconductors program, supporting projects that cultivate a broad coalition of researchers from across science and engineering communities to use a holistic, co-design approach to fundamental research, education, and training and to enable rapid progress in new semiconductor technologies. In FY 2024, IUSE anticipates continuing its investments to support innovations in the two-year college STEM education[5] sector, which encourage investigators and projects to (1) center students in the effort to advance innovation and promote equitable outcomes in STEM education at two-year colleges, and (2) enhance the capacity of two-year colleges to harness the talent and potential of their diverse student and faculty population through innovative disciplinary, multi-department, and college-wide efforts. With more than 1,000 two-year colleges enrolling over 11 million students, these institutions provide STEM education to a large population of students entering the STEM workforce and are critical to our STEM competitiveness. Among U.S. students who earned Science & Engineering bachelor's degrees between 2010 and 2017, about half (47 percent) had done some coursework at a community college and nearly a fifth (18 percent) earned associate degrees.

IUSE was initiated as a multi-year, NSF-wide priority investment area, originally spanning FY 2014 to FY 2020. Now, in its tenth year, the program continues to promote novel, creative, and transformative approaches to generating and using new knowledge about STEM teaching and learning that lay the groundwork for institutional improvement in STEM education. In addition, the program continues to improve diversity of students and faculty participation in STEM education, and knowledge mobilization and adoption of new and effective pedagogical practices. The IUSE program demonstrates NSF's substantial commitment to the highest caliber of undergraduate STEM education utilizing the Foundation-wide framework of investments. It is also closely aligned with the agency's priority to inspire the Missing Millions in STEM, better serving and meeting the teaching and learning needs of those student populations often under-cultivated and underserved in STEM.

Goals

IUSE supports improvements in undergraduate STEM education across the Nation by funding research, development, and implementation efforts that will:

1. *Improve Undergraduate STEM Learning and Learning Environments:* Investments will build the knowledge base for innovative undergraduate STEM instruction and evidence-based pedagogical and professional development practices.
2. *Broaden Participation and Institutional Capacity for Undergraduate STEM Learning:* Investments will increase the number and diversity of undergraduate students in STEM majors and career pathways and build the knowledge base for how to do so.

[5] https://beta.nsf.gov/funding/opportunities/advancing-innovation-and-impact-undergraduate-stem-education-two-year

3. *Build the STEM Workforce for Emerging Industries:* Investments will advance the preparation of undergraduate students to be successful in today's STEM classrooms and, equally important, productive members of the future STEM and STEM-capable workforce.

FY 2024 Investments

As part of ISUE's mission to advance STEM, NSF plans to invest $108.15 million in IUSE in FY 2024. It is one of the anchor undergraduate investments made by EDU, supporting research and development activities, such as studying the use of inquiry-based and active learning approaches in undergraduate instruction, increasing undergraduate research experiences and courses, and research on the persistence and graduation of students in STEM programs. IUSE is complemented by six additional EDU core programs, sharing three common IUSE goals listed in the previous section but have more specific funding goals than IUSE: EDU:

- EDU – *IUSE: Hispanic Serving Institutions (HSI) Program*: Funds improvements in retention and graduation rates at HSIs that have not received high levels of NSF support; Estimated Number of Awards: 40.
- EDU – *IUSE: Innovations in Two Year College STEM Education (ITYC):* Supports STEM education initiatives which enhance STEM teaching and learning at two-year colleges; Estimated Number of Awards: 20.
- BIO – *IUSE: Research Coordination Networks/Undergraduate Biology Education (RCN-UBE)*: Encourages collaborative networks to improve undergraduate biology education; Estimated Number of Awards: 12.
- ENG – *IUSE/Professional Formation of Engineers: Revolutionizing Engineering Departments (IUSE/PFE:RED)*: Supports organizational change strategies to transform undergraduate engineering education; Estimated Number of Awards: 5 to 10.
- CISE – IUSE: Computing in Undergraduate Education (IUSE:CUE): Champions collaborative partnerships to re-envision how to teach computing effectively in a scalable manner focusing on those undergraduate students from groups underserved by traditional computing courses and careers; Estimated Number of Awards: 6.
- GEO – IUSE: Pathways into the Geosciences - Earth, Ocean, Polar and Atmospheric Sciences (GEOPAths): Supports projects that specifically address the current needs and opportunities related to education, learning, training and professional development within the geosciences community through the formation of STEM Learning Ecosystems that engage students in the study of the Earth, its oceans, polar regions and atmosphere; Estimated Number of Awards: 15.

IUSE funding focuses on advancing the Nation’s vision of an undergraduate STEM education enterprise in which every undergraduate becomes STEM-knowledgeable and all students who desire to can pursue a STEM education that maximizes their full potential for a STEM career.

MAJOR INVESTMENTS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) GRADUATE STUDENTS AND GRADUATE EDUCATION

Overview

Continued assurance of U.S. global competitiveness in STEM requires that academia, government, and industry have access to talent that can make contributions across the STEM disciplines and that also reflects the diversity of the US population. High-quality graduate education programs, across the Nation, are preparing future STEM leaders, researchers, and professionals to make revolutionary breakthroughs; to increase industrial competitiveness; to promote ethical decision-making; and contribute to the Nation's overall security, economic prosperity, and social wellbeing. Important resource allocations in graduate education are investments in the long-term viability of the U.S. STEM enterprise. Grand challenges related to salient national STEM priorities, such as cybersecurity, microelectronics, STEM teaching and learning, artificial intelligence, climate change, quantum computing, and many others will be successfully addressed by future STEM leaders, researchers, and professionals. There is growing awareness, as evidenced by the text of the CHIPS and Science Act of 2022, that investments in STEM graduate-level talent is critical for the future success of the Nation. As the STEM enterprise evolves, the preparation of graduate students in STEM will need to also adapt to ensure that students are equipped with the requisite knowledge, skills, and abilities to lead STEM innovation in academia and both the private and public sectors well into the future.

Aligned with current Administration and Congressional priorities, NSF invests substantial resources to support the next generation of STEM discoverers, researchers, and leaders. Such investments help to harness the needed diverse, domestic STEM talent in government, academia, and industry. Each year, NSF makes significant investments in graduate students through research assistantships funded through research awards across the agency. Other EDU investments, including those made by its Division of Graduate Education (DGE) and Division of Undergraduate Education, support individual graduate students through traineeships, scholarships, and fellowships. Additional investments promote innovations in graduate education that have the potential to enhance the graduate education experience for future STEM researchers and leaders.

Goals

The goal of NSF's investments in STEM graduate education and STEM graduate talent is to ensure that the Nation's graduate-level STEM education enterprise is prepared to produce a diverse workforce that will make transformational contributions at the frontiers of STEM; serve as leaders in STEM in academia, government, and industry; and innovate in STEM-intensive careers. This goal is based on an NSF strategic framework[1] that outlines the following specific aims:

1. *Advance Science and Engineering Research:* Support graduate students and graduate education to enable long-term contributions of new knowledge at the frontiers of science and engineering.
2. *Broaden Participation to Promote Excellence in Research and Build the Next Generation STEM Workforce:* Recruit graduate students from a variety of geographic, demographic, social, and educational backgrounds to promote the advancement of science and a highly qualified professional workforce.

[1] National Science Foundation (2016). NSF Strategic Framework for Investments in Graduate Education. National Science Foundation, Alexandria, VA. Retrieved from: www.nsf.gov/pubs/2016/nsf16074/nsf16074.pdf.

3. *Build Effective Models of Graduate Education and Workforce Development:* Support the development and use of innovative models and evidence-based approaches in graduate education, including education and research about promising practices and program effectiveness.

FY 2024 Investments

Across the agency, there are two major agency-wide programs focusing on graduate education: NSF Research Traineeship [NRT] and Graduate Research Fellowship Program [GRFP]). Both programs are under the auspices of EDU, and DGE leads management of them both, with the benefit of input from NSF-wide working groups. Both of the DGE programs support actions recommended in major national reports[2] as ways to better prepare graduates for a broad range of careers. Both programs also respond to legislative actions, such as the CHIPS and Science Act of 2022. NRT has two complementary components: (1) training grants that focus on developing researchers in high-priority interdisciplinary research areas; and (2) the Innovations in Graduate Education (IGE) research program that supports research on the development and implementation of bold, new, and potentially transformative approaches to STEM graduate education and training. GRFP identifies and supports the next generation of outstanding STEM researchers and scientists by providing them with stipend support as well as a contribution towards the costs of their education. Further, the NRT and GRFP programs provide professional development opportunities for graduate students, including internships and international research experiences. Ongoing evaluation and monitoring of the programs and students involved in NRT and GRFP provide rich data that will be used to inform future efforts to improve the graduate education experience for all students.

Several other NSF programs focus on developing sectors of the STEM workforce by supporting students and by testing new models and approaches to graduate education. For example, under DGE, the CyberCorps®: Scholarship for Service (SFS) program addresses the national cybersecurity workforce need. The Robert Noyce Teacher Scholarship program (Noyce), under EDU's Division of Undergraduate Education (DUE) provides fellowship support to members of the master teacher cohort at the graduate level and funds innovation in approaches to STEM teacher education and leadership development. Under EDU's Division of Excellence in Equity in STEM (EES), the Louis Stokes Alliances for Minority Participation's Bridge to the Doctorate (LSAMP-BD) track and DUE's NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) support the successful entry of underrepresented and underserved populations into STEM graduate education and the STEM workforce. This broad suite of programs contributes substantially to the NSF investment in the STEM research and education workforce of the future.

[2] National Academy of Sciences, Engineering, and Medicine. 2018. Graduate STEM Education in the 21st Century. Washington, DC: The National Academies Press. Retrieved from: www.nap.edu/catalog/25038/graduate-stem-education-for-the-21st-century; American Chemical Society Presidential Commission (2012). Advancing graduate education in the chemical sciences. American Chemical Society, Washington, DC. Retrieved from: www.acs.org/content/dam/acsorg/about/governance/acs-presidential-graduate-education-commission-full-report.pdf; Biomedical Research Workforce Working Group (2012). Biomedical Research Workforce Working Group Draft Report. National Institutes of Health, Bethesda. Retrieved from www.acd.od.nih.gov/documents/reports/bmw_report.pdf

NSF Research Traineeship

The goals of the NRT Program are to support highly effective training of STEM graduate students in convergent research areas of national priority, as well as to create, promote, and disseminate innovative, effective, and scalable models for effective STEM graduate student training. In FY 2024, NRT will continue to focus on providing traineeships to prepare students to lead in emerging industries.

NRT promotes interdisciplinary and convergent graduate education through two approaches: traineeships and fundamental research into graduate education. Traineeships utilize comprehensive training models that are innovative, evidence-based, and aligned with changing workforce and research needs. Such models aim to prepare STEM graduate students to contribute to high-priority interdisciplinary research areas. The training includes development of technical and professional skills for both research and research-related careers within and outside academia. NRT training components are made available to both NRT-funded students and other graduate students who may want to take advantage of these opportunities. NRT seeks to support projects at a diverse group of institution types.

Fundamental education research is addressed through the IGE component of NRT, which focuses on test-bed projects aimed at piloting, testing, and validating innovative and potentially transformative approaches to graduate education of students pursuing academic master's, professional science master's, and doctoral degrees. These approaches include activities such as career preparation, mentoring, partnerships, and internships. IGE will also support broader access to these advances for the graduate education community, including graduate faculty, staff, and graduate school administrators.

NRT Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	Relief Supplemental CHIPS +	FY 2023 Estimate Total	FY 2024 Request
$60.00	**$60.00**	**$28.50**	**$88.50**	**$62.50**

Graduate Research Fellowship Program

The goal of GRFP is to identify and nurture the STEM human capital necessary to ensure the Nation's leadership in advancing STEM research innovations, with an emphasis on broadening participation. GRFP selects, recognizes, and financially supports graduate students with demonstrated high potential for excellence in STEM careers. In FY 2024, EDU will support at least 2,500 new fellowships, with a cost of education allowance of $16,000, increased from a previous level of $12,000, and a stipend of $37,000 per fellow. Applications are welcome from students in all disciplines supported by NSF, including STEM education and interdisciplinary STEM areas. The GRFP program will continue to encourage applications in topical areas that align with NSF and Administration priorities.

GRFP Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request
	$290.01	**$230.00**	**$92.00**	**$322.00**	**$380.32**
Project Fellows on Tenure[1]	5870			6196	6742

[1] Fellowship tenure status is the period of time during which fellows actively use the fellowship award to pursue use an advanced degress in a STEM or STEM education field.

CyberCorps®: Scholarship for Service

The SFS program addresses cybersecurity education and workforce development by providing funding to institutions to support development of cybersecurity educational programs and related activities such as cyber camps, cohort building and mentoring. SFS enables awards of scholarships to undergraduate and graduate students enrolled in these educational programs. In return for their scholarships, recipients must complete a government-based internship and then gain employment after graduation in a cybersecurity-related position in a Federal, state, local, or Tribal government organization for a period equal to the duration of the scholarship. The SFS program also supports research and development to improve cybersecurity education and workforce training, particularly in emerging areas such as AI, quantum computing, and aerospace, including through investments made via the Secure and Trustworthy Cyberspace: Education program (SaTC-EDU).

SFS Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental CHIPS + Science	FY 2023 Estimate Total	FY 2024 Request
$63.00	**$74.00**	**$11.50**	**$85.50**	**$74.00**

Additional Programs and Activities Supporting STEM Graduate Education and Workforce Development

Louis Stokes Alliances for Minority Participation-Bridge to the Doctorate (LSAMP-BD)

The LSAMP program assists universities and colleges in diversifying the STEM workforce by increasing the number of STEM baccalaureate and graduate degrees awarded to individuals from populations historically underrepresented in STEM disciplines: African Americans, Alaska Natives, American Indians, Hispanic Americans, Native Hawaiians, and Native Pacific Islanders. The LSAMP program provides funding to alliances comprised of multiple degree-granting organizations that can implement comprehensive and sustained strategies that result in the graduation of well-prepared, highly qualified students from groups such as those above. The LSAMP-BD is a targeted activity through which established alliances provide post-baccalaureate fellowships to support the transition into and success of students in STEM master's and/or doctoral programs, thus increasing their entry into the STEM workforce. In FY 2024, LSAMP expects to direct about $22.5 million towards this activity.

NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM)
NSF established the S-STEM program in accordance with the American Competitiveness and Workforce Improvement Act of 1998 (P.L. 105-277), as modified by P.L. 106-313 and P.L. 108-447 in 2005. The Act reflected the national need to increase the number of American scientists and engineers. The S-STEM program provides institutions with funds for student scholarships to support low-income, academically talented U.S. students with demonstrable financial need.

Section 10393 of the CHIPS and Science Act of 2022 (Public Law. 117-167) removed language that limited the scholarship amount to $10,000 per year and lengthened the maximum scholarship duration to five years. Thus, the maximum individual scholarship amounts were increased from $10,000 to $15,000 per year for undergraduate students and from $10,000 to $20,000 per year for graduate students for maximum duration of five years.

These scholarships, together with additional supports such as mentoring and internships, help these students earn an associate, baccalaureate, or graduate degree in STEM fields. These graduates will be highly prepared to enter and contribute to the STEM workforce. The S-STEM program emphasizes the importance of recruiting students to pursue STEM disciplines, mentoring and supporting students through degree completion, and partnering with employers to facilitate student career placement in the STEM workforce. S-STEM provides individual scholarships of up to $15,000 per year for undergraduate students and up to $20,000 per year for graduate students for maximum duration of five years, depending on cost of attendance and unmet financial need. S-STEM expects to offer support for up to 250 Masters or PhD students in FY 2024. In addition to providing scholarship support, S-STEM projects also contribute to the knowledge base about effective STEM education by carrying out research on effective practices to recruit STEM students and support them to earn STEM degrees. S-STEM is funded through H-1B Nonimmigrant Petitioner Account receipts. In FY 2024, S-STEM expects to invest approximately $49.06 million in awards to support scholarships for graduate students.

Robert Noyce Teacher Scholarship (Noyce)
The Noyce program responds to the increasing need for highly effective K-12 STEM teachers and teacher leaders. Noyce supports institutions of higher education to develop and sustain comprehensive programs of study that encourage and support undergraduate STEM majors and STEM professionals to become effective K-12 STEM teachers in high-need school districts. It also supports experienced, exemplary K-12 STEM teachers to become teacher leaders in high-need school districts and to engage their colleagues in communities of practice focused on continued professional development. Section 10320 of the CHIPS and Science Act of 2022 (Public Law. 117-167) waived the mandatory cost-sharing requirements for the Noyce program for 5 years for Noyce proposals submitted to Track 2 (NSF Teaching Fellowships [TF] Track), and Track 3 (NSF Master Teaching Fellowships [MTF] Track). The TF Track supports STEM professionals becoming certified or licensed elementary, middle, or high school teachers through the completion of a master's degree, as well as receiving a salary supplement every year for four years while teaching in a high-need school district. The MTF track supports experienced and exemplary STEM teachers (elementary, middle, and high school) with only a bachelor's degree to obtain a master's degree, as well as those with a master's degree to receive a salary supplement for up to five years as they continue to teach in a high-need school district. In addition, the Noyce program funds research on the effectiveness and retention of K-12 STEM teachers in high-need school districts.

Categories of Noyce Support for Graduate Education

Track	Outcome	Eligible Individuals	Support	Length of Commitment to Teach in High-need Schools
Scholarships and Stipends	Highly effective K-12 STEM teachers in high need schools/districts	STEM professionals	One-year scholarship to become certified/licensed teacher	2 years
Teaching Fellowship			One-year Scholarship to complete a master's degree in education and salary supplement* during teaching commitment	4 years
Master Teaching Fellowships	Highly effective K-12 teacher leaders in STEM education in high need schools/districts	K-12 STEM teachers without a master's degree	One-year Scholarship to complete a master's degree and salary supplement* during teaching commitment	5 years**

**The salary supplements support participation in mentoring and professional development to increase the Fellow's effectiveness in the classroom and/or as teacher leaders.*
***The Master Teaching Fellows continue teaching in a high need school and/or school district while they are pursuing their master's degree.*

The Noyce Teaching Fellowships and Master Teaching Fellowships track expects to fund about 160 fellows in FY 2024.

Funding Workforce Development

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2023 Estimate Total	FY 2024 Request
LSAMP-BD	$8.60	$7.50	$7.50	$22.50
S-STEM	26.89	44.78	44.78	49.06
Noyce Teaching & Master Teaching Fellows (10A)	25.23	14.00	14.00	20.00
Total	**$60.72**	**$66.28**	**$66.28**	**$91.56**

RESEARCH AND RELATED ACTIVITIES (R&RA) $9,017,900,000

The FY 2024 Budget Request for the Research and Related Activities account is $9,017.90 million. Funding within the R&RA Appropriation invests in early-stage research as well as development of a future-focused science and engineering workforce that can accelerate progress in basic science and engineering research as well as support the private sector.

NSF is the only federal agency dedicated to funding basic research across all areas of non-biomedical science and engineering. In FY 2024, NSF will continue its longstanding commitment to investing in discovery and learning that will promote the innovations that help fuel the Nation's future prosperity.

R&RA Funding

(Dollars in Millions)

R&RA Organization	FY 2022 Actual[1]	FY 2023 Estimate Base[2]	Disaster Relief Supplemental			FY 2023 Estimate Total	FY 2024 Request REVISED	Change over FY 2023 Base Total[3]	
			Base	CHIPS and Science	RI Damage Mitigation			Amount	Percent
Biological Sciences	$831.61	$831.73	$25.25	-	-	$856.98	$972.41	$115.43	13.5%
Computer & Info. Science & Engineering	1,014.72	1,010.57	40.00	-	-	1,050.57	1,172.14	121.57	11.6%
Engineering	774.53	774.80	34.00	-	-	808.80	970.00	161.20	19.9%
Geosciences Programs	1,035.73	1,032.26	35.89	-	-	1,068.15	1,236.38	168.23	15.8%
GEO: Office of Polar Programs	544.68	545.16	-	-	-	545.16	565.60	20.44	3.7%
U.S. Antarctic Logistics Activities	*85.00*	*94.20*	-	-	-	*94.20*	*102.00*	7.80	8.3%
Mathematical & Physical Sciences	1,615.26	1,612.90	70.44	-	2.50	1,685.84	1,835.79	152.45	9.1%
Social, Behavioral & Economic Sciences	285.86	285.82	27.38	-	-	313.20	360.60	47.40	15.1%
Technology, Innovation, & Partnerships	413.09	450.00	220.00	210.00	-	880.00	1,185.63	515.63	77.0%
Office of Intern'l Science & Engineering	54.23	61.32	8.00	-	-	69.32	71.21	1.89	2.7%
Integrative Activities	393.30	399.83	147.20	-	-	547.03	646.37	99.34	18.2%
U.S. Arctic Research Commission	1.66	1.75	-	-	-	1.75	1.77	0.02	1.1%
Total	**$6,964.66**	**$7,006.14**	**$608.16**	**$210.00**	**$2.50**	**$7,826.80**	**$9,017.90**	**$1,403.60**	**18.4%**

[1] Excludes $277.11 million provided by the American Rescue Plan supplemental appropriation.

[2] Reflects the proposed transfer of $15.0 million from R&RA to AOAM as part of the Current Plan request, still pending prior to publication. This information differs from what is shown in the President's Budget Request, which shows NSF's Enacted FY 2023 funding levels.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For more information on R&RA appropriations language and carryover see the Technical Information Chapter.

DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO) $972,410,000

Directorate for Biological Sciences (BIO)

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change Over FY 2023 Base Total[2] Amount	Percent
Division of Molecular and Cellular Biology (MCB)	$156.74	$147.00	-	$147.00	$157.02	$10.02	6.8%
Division of Integrative Organismal Systems (IOS)	208.40	197.45	-	197.45	214.96	17.51	8.9%
Division of Environmental Biology (DEB)	180.10	169.81	-	169.81	188.55	18.74	11.0%
Division of Emerging Frontiers (EF)	89.17	108.97	25.25	134.22	183.96	49.74	37.1%
Division of Biological Infrastructure (DBI)	197.20	208.50	-	208.50	227.92	19.42	9.3%
Total	**$831.61**	**$831.73**	**$25.25**	**$856.98**	**$972.41**	**$115.43**	**13.5%**

[1] Excludes $43.53 million in American Rescue Plan supplemental funding.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About BIO

BIO supports fundamental research and infrastructure that promotes a unified understanding of all forms of life and at all scales, from molecules to populations of organisms, and species that underpin the functioning of the Nation's ecosystems, as well as across time and geographic diversity. It also supports the human capital necessary to enable this research. The knowledge gained advances fields from agriculture to climate change mitigation and conservation, biotechnology and biomedicine, and more. In the past decade, biology has been transformed by new technologies and has transformed other areas of science and engineering from computer and information sciences, engineering, and the mathematical and physical sciences. BIO seeks to capitalize on these advances to vastly improve our ability to understand life's deepest mysteries and enable new capabilities to modify organisms and ecosystems for societal benefit. Harnessing life's evolutionary innovations is the key to driving the Nation's bioeconomy, and BIO's support for foundational and translational research promotes economic prosperity, health, and security by addressing existing and future global challenges.

BIO's scientific investments align directly with Administration priorities, including biotechnology to promote the bioeconomy, environmental forecasting and mitigating the impacts of global warming on essential ecosystem services, predicting and preventing the emergence of infectious diseases, and increasing racial equity and diversity across the STEM enterprise. BIO investments in genomics, in cellular, organismal, and developmental biology, and in bioinformatics spur further development of capabilities in synthetic biology and enhance biotechnology beyond the current state-of-the-art. The accelerating power of this advanced biotechnology promises to sustain U.S. economic growth and innovation across multiple sectors including agriculture, biomanufacturing, pharmaceuticals, and other bioproducts. BIO investments in biotechnology also aid development of a circular bioeconomy that reduces carbon emissions and creates new sources of clean energy. BIO investments in ecology, evolution, and biodiversity, including support for the National Ecological Observatory Network (NEON), promote the development of dynamic, eco-forecasting models to predict climate change impacts at local, national, and even global scales. BIO investments in life's innovations will similarly focus on understanding the adaptive potential of species and ecosystems to respond to climate change stressors such as ocean acidification, sea level rise, droughts, flooding, fires, and other extreme events. Together, these investments are responsive to the national need to understand and develop solutions for the climate emergency. BIO will continue to invest in research on infectious disease emergence and transmission, contribute to the goal of preventing future pandemics, and fill

knowledge gaps concerning the spread and evolution of biothreats. BIO will build upon the foundational knowledge gained through Understanding Rules of Life (URoL) – of how key properties of living systems emerge from complex interactions – by focusing on Using the Rules of Life. This will support convergent, use-inspired research in biotechnology to address pressing societal challenges and grow and sustain a vibrant bioeconomy by creating new jobs and industries.

Biological questions often drive convergence research across multiple fields of science and technology and stimulate applications that enhance economic and national security, as well as societal well-being. Pursuits in the biological sciences to quantify living systems at all scales have propelled the frontiers of research in statistics, mathematics, and computer sciences to consider larger and more complex data sets that benefit from artificial intelligence (AI) and machine learning. Foundational research on microbes and their interactions with plants leverages these advances in data analytics using AI and advanced computing to fuel a revolution in agriculture. Similarly, collaborations between the biological and physical sciences have contributed to advances in biomaterials and other bio-inspired products, biological computing, and semiconductors, which exploit the extraordinary information density in genetic polymers, and neuro-technologies that power advances in neuroscience and cognition. Quantum biology, the application of quantum theory to biological systems, provides new insights into the power of photosynthesis for energy production as well as a fundamental understanding of vision, smell, magnetoreception, and other sensing systems. This research will enable bioinspired designs based on quantum energy production and sensing systems that will enhance American security.

Tackling bold questions in biology increasingly requires an integrated approach that leverages advances from multiple subdisciplines and incorporates cutting-edge methods, tools, and concepts. Such research is critical to inform solutions to societal challenges, including natural resource management, resilience to environmental change, and global food security. In FY 2024, BIO will invest in integrative, convergent, and team science; fundamental and use-inspired research aimed at addressing grand societal challenges; and in emerging industries, such as biotechnology, through existing core programs and a new effort focused on establishing BioFoundries. Special calls like Organismal Response to Climate Change (ORCC) and Biodiversity on a Changing Planet (BoCP), and programs aimed at addressing and overcoming the continuing challenge of integrating across subdisciplines and approaches, such as the Biology Integration Institutes (BII), will receive additional key funding. In FY 2024, BIO is also increasing its investment in synthesis centers, centers focused on integration and reuse of existing data to create new knowledge that will fuel advances in both basic and use inspired research across all scales of biological organization. BIO investments in these integration programs represent major funding opportunities to encourage cooperative research seeking a holistic understanding of how living systems function. These institute awards, and others across BIO, will result in highly collaborative, team-science endeavors, which also fosters diversity and inclusion in science.

BIO will continue supporting investments in building and broadening the biological sciences workforce through postdoctoral fellowships, Building Research Capacity of New Faculty in Biology (BRC-BIO), postbaccalaureate scholars (Research and Mentoring for Post baccalaureates in Biological Sciences (RaMP), and cultural change to ensure an inclusive environment that contributes to retention of these individuals (Leading Culture Change through Professional Societies of Biology (BIO-LEAPS). BIO currently provides 65 percent of the federal funding for basic research at academic institutions in the life sciences.

Major Investments

BIO Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Estimate Base Total[3] Amount	Change over FY 2023 Estimate Base Total[3] Percent
Advanced Manufacturing	$7.16	$7.16	$7.16	-	-
Artificial Intelligence	20.00	20.00	20.00	-	-
BioFoundries	-	30.00	30.00	-	-
Biotechnology	118.00	148.00	176.88	28.88	19.5%
Climate: Clean Energy Technnology	50.00	55.00	74.50	19.50	35.5%
Climate: USGCRP	162.01	211.71	237.07	25.36	12.0%
Improving Undergraduate STEM Education	2.12	1.50	5.00	3.50	233.3%
Quantum Information Science	3.28	3.28	3.28	-	-

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about cross-agency themes and initiatives supported by BIO, such as Advanced Manufacturing, Artificial Intelligence, Climate (Clean Energy Technology, USGCRP), Quantum Information Science, Improving Undergraduate STEM Education, National Nanotechnology Initiative, and NSF's Big Ideas, see individual narratives in the NSF-Wide Investments chapter.

- BioFoundries: The BioFoundries program supports collaborative teams of researchers and technology developers who will generate the technologies, instrumentation, workflow pipelines, and advanced computing that will enable the advancement of biology, biotechnology, bioengineering and biomanufacturing. As a steward of this agency-wide program, the FY 2024 request of $30 million is expected to support 2 or 3 new BioFoundry awards.

- Biotechnology: Biotechnology comprises the data, tools, research infrastructure, workforce capacity, and innovation that enable the discovery, utilization, and reprogramming of living organisms, their constituent components, and their biologically related processes. For more information, see the Biotechnology narrative in the NSF-Wide Investments chapter.

Centers Programs

BIO Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
Artificial Intelligence Research Institutes (Multiple)	-	$1.00	$1.00	-	-
Biology Integration Institutes (Multiple)	25.90	35.20	53.68	18.48	52.5%
Centers for Analysis & Synthesis (DBI)	1.50	2.50	6.50	4.00	160.0%
STC: Biology with X-ray Lasers (DBI)	3.32	-	-	-	N/A
STC: Center for Cellular Construction (DBI)	5.00	5.00	5.00	-	-
STC: Center for Research on Programmable Plant Systems (DBI)	5.00	5.00	5.00	-	-
Total	**$40.72**	**$48.70**	**$71.18**	**$22.48**	**46.2%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For Organization detail on the People Numbers and Funding Profile tables, please see the Summary Tables chapter.

BIO Major Facilities

BIO Funding for Major Facilities

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
National Ecological Observatory Network (NEON)	$69.01	$71.71	$78.04	$6.33	8.8%

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual facilities, please see the Research Infrastructure section of the NSF-Wide Investments chapter.

DIVISION OF MOLECULAR AND CELLULAR BIOSCIENCES (MCB)

MCB Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$156.74**	**$147.00**	**$157.02**	**$10.02**	**6.8%**
Research	145.71	145.00	154.02	9.02	6.2%
Education	9.71	1.00	2.00	1.00	100.0%
Infrastructure	1.32	1.00	1.00	-	-

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

MCB supports fundamental interdisciplinary research to uncover the basic principles that describe cellular function at the molecular level, including (a) how information content in cells is maintained and transmitted to the next generation and guides expression of cellular characteristics; (b) how material and energy are absorbed, transformed, and flow through biological system; and (c) how biological molecules assemble into complex structures and compartments with varied functions. In general, about 77 percent of the division portfolio is available to support new research grants. The remaining 23 percent supports research grants made in prior years.

DIVISION OF INTEGRATIVE ORGANISMAL SYSTEMS (IOS)

IOS Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$208.40**	**$197.45**	**$214.96**	**$17.51**	**$0.09**
Research	178.60	183.65	200.16	16.51	9.0%
Education	12.43	3.80	4.80	1.00	26.3%
Infrastructure	17.37	10.00	10.00	-	-

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

IOS supports fundamental research and training focused on mechanistic analyses of the functional phenotypic characteristics of diverse organisms, prioritizing integrative research linking biological molecules to complex populations through understanding the processes that build and maintain diverse organisms in the contexts in which they function. In general, about 62 percent of the division portfolio is available to support new research grants. The remaining 38 percent supports research grants made in prior years.

DIVISION OF ENVIRONMENTAL BIOLOGY (DEB)

DEB Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$180.10**	**$169.81**	**$188.55**	**$18.74**	**11.0%**
Research	168.18	168.31	186.05	17.74	10.5%
Education	9.83	1.50	2.50	1.00	66.7%
Infrastructure	2.09	-	-	-	N/A

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

DEB supports fundamental research on Earth's biodiversity and the ecological and evolutionary processes that explain the origin and maintenance of genetic variation in living systems, including its history and patterns of speciation and extinction. In general, about 72 percent of the division portfolio is available to support new research grants. The remaining 28 percent supports research grants made in prior years.

DIVISION OF EMERGING FRONTIERS (EF)

EF Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$89.17**	**$108.97**	**$25.25**	**$134.22**	**$183.96**	**$49.74**	**$0.37**
Research	84.66	73.18	25.25	98.43	124.96	26.53	27.0%
Education	4.51	34.79	-	$34.79	58.00	23.21	66.7%
Infrastructure	-	1.00	-	$1.00	1.00	-	-

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

EF serves as an incubator for innovation and integration within the biological sciences. It supports research that transcends scientific disciplines and advances conceptual foundations across all levels of biological organization. Innovative research and infrastructure activities in BIO typically begin development in EF and then move to other BIO divisions to become part of the disciplinary knowledge base. In general, about 81 percent of the division portfolio is available to support new research grants. The remaining 19 percent supports research grants made in prior years.

DIVISION OF BIOLOGICAL INFRASTRUCTURE (DBI)

DBI Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$197.20**	**$208.50**	**$227.92**	**$19.42**	**9.3%**
Research	48.96	60.60	77.13	16.53	27.3%
Education	31.76	25.50	29.00	3.50	13.7%
Infrastructure	116.48	122.40	121.79	-0.61	-0.5%

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

DBI empowers biological discovery by investing in the innovation and capacity-building of cutting-edge research infrastructure for fundamental biological science, which includes human capital, technologies, institutes and centers, and mid- to-large scale infrastructure. In general, about 22 percent of the division portfolio is available to support new research grants. The remaining 78 percent supports continuing grant increments and cooperative agreements for research infrastructures.

DIRECTORATE FOR COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE) **$1,172,140,000**

CISE Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Office of Advanced Cyberinfrastructure (OAC)	$230.52	$230.54	$22.00	$252.54	$282.54	$30.00	11.9%
Computing and Communication Foundations (CCF)	201.06	200.00	3.00	203.00	224.21	21.21	10.4%
Computer and Network Systems (CNS)	243.10	241.12	8.00	249.12	281.23	32.11	12.9%
Information and Intelligent Systems (IIS)	217.85	218.87	2.00	220.87	254.12	33.25	15.1%
Information Technology Research (ITR)	122.20	120.04	5.00	125.04	130.04	5.00	4.0%
Total	**$1,014.73**	**$1,010.57**	**$40.00**	**$1,050.57**	**$1,172.14**	**$121.57**	**11.6%**

[1] Excludes $30.12 million in American Rescue Plan supplemental funding.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About CISE

CISE's mission is to promote the progress of computer and information science and engineering research and education, and advance the development and use of cyberinfrastructure (CI) across the science and engineering research enterprise; to promote understanding of the principles and uses of advanced computer, communication, and information systems in advancing science and engineering and in service to society; and to contribute to universal, transparent, and affordable participation in a knowledge-based society. CISE supports ambitious research and research infrastructure projects within and across the many subfields of computing, as well as advanced research CI for all areas of science and engineering; contributes to the education and training of computing and information professionals; and more broadly, informs the preparation of a U.S. workforce with computing, computational, and information competencies essential for success in an increasingly competitive global and digital market. Essentially all practical applications of today's IT are based on ideas and concepts that emerged from investments in fundamental computing and information research, many of them funded by CISE.[1]

In FY 2024, CISE will continue to play a leadership role in Advancing Emerging Industries for National and Economic Security through seminal investments in AI, advanced computing systems and services including high-performance computing (HPC), quantum information science (QIS), advanced communications technologies, advanced manufacturing, semiconductors and microelectronics, biotechnology, cybersecurity, and disaster response and resilience. As part of these investments, In FY 2024 CISE will support the Accelerating Computation-Enabled Discovery program that will revolutionize our understanding of every field of fundamental and applied science through expanded investments in AI, computational modeling and simulation, data driven discovery, and formal analysis and theorem provers. CISE will also continue its investments in the SaTC program that supports research to advance the fields of cybersecurity and privacy, including through information integrity, through a re-examined SaTC program.

In FY 2024, CISE will continue its investments in Building a Resilient Planet through the development

[1]www.nap.edu/catalog/25961/information-technology-innovation-resurgence-confluence-and-continuing-impact

of a National Discovery Cloud for Climate (NDC-C). This resource will federate advanced compute, data, software and networking resources, democratizing access to a cyberinfrastructure ecosystem that is increasingly necessary to further climate-related S&E. The NDC-C will serve as a pilot for future efforts to enable equitable access to a NDC across all fields of S&E. CISE will also support investments in designing the next generation of computing systems that explore novels ways to not only dramatically increase energy efficiency but also incorporate clean energy technologies in the entire computing lifecycle.

CISE, through OAC, will continue to co-chair the National Artificial Intelligence Research Resource (NAIRR) Task Force until its termination in April 2023. The NAIRR Task Force is a Congressionally chartered Federal Advisory Committee charged with developing a roadmap and implementation plan for a shared computing and data infrastructure that would provide a diverse set of researchers and students across the broad spectrum of AI research and development with access to a holistic ecosystem of resources to fuel AI discovery and innovation. A key goal of the NAIRR is to democratize access to these advanced resources, thereby engaging a broad and diverse population in cutting-edge AI research and innovation. The envisioned NAIRR complements the NDC-C described above. The NAIRR along with the NDC-C will support the NSF priority in Strengthening Research Infrastructure.

CISE investments foster and support research and teaching environments that promote equity. In alignment with an agency-wide emphasis on Creating Opportunities Everywhere, CISE will continue to invest in a broad suite of activities to support broadening participation in research and education in CISE fields and STEM more generally. For example, in alignment with the INCLUDES Initiative, the Broadening Participation in Computing Alliances (BPC-A) will serve as broad coalitions of institutions of higher education, K-12 schools, government, industry, professional societies, and other not-for-profit organizations that design and carry out comprehensive programs addressing underrepresentation in the computing and information science disciplines. CISE will also broaden participation in computing by increasing engagement in CISE-funded research projects from MSIs through the CISE-MSI program and will emphasize education and training of more U.S. based students from diverse backgrounds through CISE Graduate Fellowships (CSGrad4US).

In FY 2024, CISE, through OAC, will continue to provide NSF's co-leadership of the Future Advanced Computing Ecosystem (FACE).[2] As part of its support for FACE, CISE investments support the full breadth of NSF-funded S&E by enabling shared resources and improved capabilities across a range of disciplines, a diverse set of users within many academic institutions, and a wide range of science and engineering advances. CISE will also continue to provide leadership for the Federal Government's Networking and Information Technology Research and Development (NITRD) program. The NITRD Subcommittee of the National Science and Technology Council (NSTC), which coordinates investments in networking and information technology research and development across more than 20 federal departments, agencies, and offices, is co-chaired by the NSF assistant director for CISE. All research, education, and research infrastructure projects supported by CISE contribute to NSF's NITRD portfolio.

Finally, CISE will build, strengthen, and expand strategic, multisector partnerships, including those with other NSF units, other federal agencies, private industry and foundations, and international funders, as an increasingly important means to maximize the scientific, economic, and societal impacts of the directorate's investments.

[2] www.nitrd.gov/pubs/Future-Advanced-Computing-Ecosystem-Strategic-Plan-Nov-2020.pdf

Major Investments

CISE Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Estimate Base Total[3] Amount	Change over FY 2023 Estimate Base Total[3] Percent
Advanced Manufacturing	$45.24	$44.30	$44.40	$0.10	0.2%
Advanced Wireless Research	89.45	88.76	93.26	4.50	5.1%
Artificial Intelligence	346.96	344.00	389.00	45.00	13.1%
Biotechnology	9.65	6.92	6.92	-	-
Climate: Clean Energy Technnology	29.28	39.50	39.50	-	-
Climate: USGCRP	-	30.00	30.00	-	-
CSGrad4US	-	8.50	12.50	4.00	47.1%
Microelectronics/Semiconductors	41.00	40.00	40.00	-	-
Quantum Information Science	25.03	20.70	24.74	4.04	19.5%
Secure & Trustworthy Cyberspace	73.53	75.00	75.00	-	-

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about cross-agency themes and initiatives supported by CISE, including Advanced Manufacturing, Advanced Wireless, Artificial Intelligence, Biotechnology, Climate (Clean Energy Technology, USGCRP), Microelectronics/Semiconductors, Quantum Information Science, National Nanotechnology Initiative, Networking and Information Technology R&D, the Big Ideas, see individual narratives in the NSF-Wide Investments chapter.

- Advanced Wireless Research: CISE will continue to invest in research in advanced wireless networks, building on its track record of enabling early-stage successes in 5G through ground-breaking millimeter-wave research. In partnership with the private sector and other federal agencies, CISE will accelerate research in areas with potential significant impact on emerging Next-Generation (NextG) wireless and mobile communications, networking, sensing, and computing systems, with a focus on greatly improving the resiliency and intelligence of such networked systems, through the Resilient & Intelligent NextG Systems (RINGS) program and other related investments.

- Artificial Intelligence (AI): CISE, together with other NSF directorates/offices, other federal agencies, and the private sector, will increase support for AI research and development. A key focal point will be support for the National AI Research Institutes. Through the program CISE, in partnership with other NSF directorates, will significantly broaden participation in AI research, education, and workforce development through capacity development projects such as ExpandAI, through CISE core investments, and through partnerships within the National AI Research Institutes ecosystem. CISE will also provide support for the NAIRR to democratize access to

advanced computing and data resources, thereby engaging a broad and diverse population.

- CSGrad4US Graduate Fellowships: CISE will select, recognize, and financially support early-career individuals with the demonstrated potential to be high-achieving CISE researchers and innovators, with the goal of developing the national workforce necessary to ensure the Nation's continued leadership in advancing CISE research and innovation. Through this investment, CISE aims to increase the number and diversity of domestic graduate students pursuing graduate degrees and research and innovation careers in the CISE fields—computer science, computer engineering, and/or information science—and broaden participation among groups underrepresented in these areas.

- Secure and Trustworthy Cyberspace (SaTC): CISE will continue to lead SaTC in partnership with EDU, ENG, MPS, and SBE, investing in current and emerging areas of importance for security and privacy. These areas include the application of AI to security, security and resilience of AI systems, security implications of quantum computation and communication, information integrity, and critical infrastructure security. CISE will fund programs that strengthen the national cybersecurity workforce pipeline through education, K-12 programs, and funding to universities and colleges.

Centers Programs

CISE Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Change over FY 2023 Estimate Base Total[1] Percent
Artificial Intelligence Research Institutes (Multiple)	$31.09	$19.95	$33.92	$13.97	70.0%

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For detail on the People Numbers and Funding Profile, please see the Summary Tables chapter.

OFFICE OF ADVANCED CYBERINFRASTRUCTURE (OAC)

OAC Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$230.52**	**$230.54**	**$22.00**	**$252.54**	**$282.54**	**30.00**	11.9%
Research	73.30	78.44	-	78.44	88.44	10.00	12.7%
Education	22.67	22.30	-	22.30	22.30	-	-
Infrastructure	134.55	129.80	22.00	151.80	171.80	20.00	13.2%

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

OAC supports the conceptualization, design, and implementation of the advanced research cyberinfrastructure (CI) ecosystem that is critical to advances in all areas of science and engineering research and education by enabling data science, artificial intelligence and machine learning, and predictive and high-end computational modeling and simulation. OAC investments also support training and workforce development and nurture the computational and data skills and expertise needed for next-generation science and engineering research. OAC enables researchers to address complex and multidisciplinary discovery, prediction, and innovation challenges by providing access to CI resources and services, along with secure connectivity to major facilities and scientific instruments.

DIVISION OF COMPUTING AND COMMUNICATION FOUNDATIONS (CCF)

CCF Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$201.06**	**$200.00**	**$3.00**	**$203.00**	**$224.21**	**21.21**	**10.4%**
Research	189.79	187.70	1.00	188.70	209.41	20.71	11.0%
Education	9.61	10.70	2.00	12.70	13.20	0.50	3.9%
Infrastructure	1.66	1.60	-	1.60	1.60	-	-

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

CCF supports research and education activities involving the mathematical, scientific, and technological foundations of computing, communication, and information. CCF's investments enable advances in the design and analysis of algorithms, computational complexity, and mathematical modeling of systems, with attention to the efficiency, fairness, correctness, and robustness of systems including AI systems. CCF also invests in foundational research on the theoretical underpinnings of information acquisition, transmission, and processing in communication and information networks, such as sensor, advanced wireless, multimedia, and biological networks. In addition, CCF provides support for advancing the design, validation, verification and evaluation of computing hardware and software through new theories, programming languages, testing approaches, and formal methods for improving system performance, safety, usability, reliability, and scalability.

DIVISION OF COMPUTER AND NETWORK SYSTEMS (CNS)

CNS Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$243.10**	**$241.12**	**$8.00**	**$249.12**	**$281.23**	**32.11**	**12.9%**
Research	204.90	206.62	1.00	207.62	232.58	24.96	12.0%
Education	12.27	12.70	4.00	16.70	19.20	2.50	15.0%
Infrastructure	25.93	21.80	3.00	24.80	29.45	4.65	18.8%

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

CNS supports research and education activities that advance understanding of the fundamental properties of computer systems and networks and plays a leadership role in coordinating CISE investments in systems research infrastructure. CNS investments produce new insights into the dynamics of complex hardware and software systems and explore new architectures for future-generation computing and communication infrastructures and services. CNS also supports research and education activities in cybersecurity to ensure that society's ubiquitous computing and communication infrastructures deliver the quality of service they are designed to achieve without disruption, while enabling and preserving privacy, security, and trust. In addition, CNS supports research-based pilot projects that have the potential for scalable, sustainable, and transferable impact on communities, from small to large, and rural to urban—across the US.

DIVISION OF INFORMATION AND INTELLIGENT SYSTEMS (IIS)

IIS Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$217.85**	**$218.87**	**$2.00**	**$220.87**	**$254.12**	**33.25**	**15.1%**
Research	203.70	205.77	-	205.77	238.52	32.75	15.9%
Education	11.15	11.10	2.00	13.10	13.60	0.50	3.8%
Infrastructure	3.00	2.00	-	2.00	2.00	-	-

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

IIS supports research and education activities that advance our knowledge in the interrelated roles of people, computers, and information. The range of research topics within these areas is broad and encompasses several significant subareas of computing: artificial Intelligence, which includes work on knowledge representation and reasoning, deep learning and machine learning, human language technologies, robotics and computer vision; data science, which includes data collection and management, data integration, data mining and analytics, and informatics; and human centered interaction, which includes usability, interfaces, assistive technology, and the social impacts of computing. IIS also invests in efforts to understand the impact of intelligent information systems on society.

DIVISION OF INFORMATION TECHNOLOGY RESEARCH (ITR)

ITR Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$122.20**	**$120.04**	**$5.00**	**$125.04**	**$130.04**	**5.00**	**4.0%**
Research	109.03	113.14	-	113.14	112.50	-0.64	-0.6%
Education	0.80	1.00	-	1.00	1.50	0.50	50.0%
Infrastructure	12.37	5.90	5.00	10.90	16.04	5.14	47.2%

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

ITR provides support for transformative explorations in computer and information science and engineering research, infrastructure, and education, which are foundational for a wide range of emerging industries. These investments support emerging and urgent high-priority areas that cut across traditional disciplinary boundaries and promise to accelerate discovery at the frontiers of the field. This includes support for foundational research on AI, QIS, particularly quantum computation and communication, and advanced wireless as well as the development of world-class research infrastructure. ITR further catalyzes research through innovative partnerships and collaborations between academia and industry.

APPENDIX A – ADVANCED COMPUTING SYSTEMS AND SERVICES PORTFOLIO

Advanced Computing Systems and Services Funding
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request
Leadership Class Computing	$15.50	$12.00	$26.00
Advanced/Innovative Computing Systems and Services	26.63	50.00	36.00
Coordination and Support Services	52.99	37.50	38.00
Total	**$95.12**	**$99.50**	**$100.00**

Advanced Computing Systems and Services Overview

For nearly four decades, NSF has been a recognized leader in enabling the innovative use and broad availability of a cohesive, powerful, and advanced computing ecosystem to accelerate fundamental science and engineering (S&E) research. Going forward, NSF aims to sustain the Nation's leadership in the research, development, and broad deployment of existing as well as new advanced computing technologies, services, and skills, in part through its co-leadership of the all-of-government National Science and Technology Council (NSTC) Future Advanced Computing Ecosystem (FACE) Subcommittee efforts. Within the broad goals set for the FACE[3,4] and as further elaborated by the NSTC FACE Subcommittee, key NSF foci include fundamental and translational research to support future generations of the advanced computing ecosystem; research cyberinfrastructure (CI) including software and data services to promote cohesive platforms and interoperability for large-scale data analytics as well as modeling and simulation applications across all of S&E; and the CI expertise necessary for advancing the frontiers of CI as well as enabling S&E discovery and innovation using CI. These foci include an emphasis on a holistic approach to the Nation's computational and data infrastructure for S&E research, spanning both human and technical dimensions, and involve forging and expanding partnerships that ensure the Nation's leadership in science, technology, and innovation. For example, during the novel coronavirus disease 2019 (COVID-19) pandemic, NSF's suite of complementary advanced computing systems and coordination services were mobilized as key contributors to the COVID-19 High-Performance Computing (HPC) Consortium, a public-private partnership that NSF helped co-found to support cutting-edge scientific research in epidemiology, virology, and microbiology, among other topics.[5]

The overall NSF advanced computing strategy and program portfolio receives guidance and input from the Advisory Committee on Cyberinfrastructure (ACCI); the Assistant Directors (AD) Council, which includes ADs and office heads from the NSF research and education directorates and offices; the Cyberinfrastructure Strategy Committee, which includes senior leadership from the NSF research and education directorates and offices, and directly from the research community through multiple sources including principal investigator meetings, workshops, sessions at professional conferences,[6] community blue-ribbon studies, and Requests for Information (RFIs). In 2019, NSF funded a conference focused on the *National Cyberinfrastructure Coordination Service Conference*, which

[3] www.nitrd.gov/news/2020/Future-Advanced-Computing-Ecosystem-Strategic-Plan-Nov-2020.aspx
[4] www.nsf.gov/cise/nsci/
[5] www.covid19-hpc-consortium.org/
[6] See, for example, https://sc20.supercomputing.org/proceedings/bof/bof_pages/bof143.html

examined the configuration of services intrinsic to a national CI.[7] Later in the year, NSF issued a RFI asking for input on "specific data-intensive S&E research questions and challenges and the essential data-related CI services and capabilities needed to publish, discover, transport, manage and process data in secure, performant and scalable ways to enable data-intensive research."[8] Although focused primarily on data and software CI, the responses to this RFI[9] have implications for the architectures of future advanced computing systems and the services associated with maintaining and operating them. In August and September 2020, NSF sponsored the CI Workforce Development Workshop[10] focused on issues related to building and enhancing the cyberinfrastructure professional workforce. Additionally, international activities to accelerate investments in leadership-class computing, particularly in Europe and Asia, are providing additional urgency and importance for this investment strategy to ensure that the U.S. maintains its global leadership role in S&E.

In response to rapid advances in technology, changes in the capabilities and services offered by commercial interests (e.g., cloud services), and the rapid evolution of S&E research requirements, in FY 2019, NSF released a forward-looking computational ecosystem blueprint, "Transforming Science Through Cyberinfrastructure". [11]

In alignment with this blueprint, NSF invests in three broad and complementary advanced computing areas that enable it to meet continually evolving needs in an agile yet predictable way. These investment areas complement each other as well as discipline-specific investments by NSF's directorates, mission-specific investments by other agencies, and cumulatively extensive, but individually smaller, investments by academic institutions at the regional and campus levels. Specifically, these areas are:

- **Leadership-Class Computing**, which aims to provide unique services and resources to advance the largest and most computationally intensive S&E research frontiers not otherwise possible;
- **Advanced/Innovative Computing Systems and Services**, which aims to provide a technically diverse, connected, and potentially future-looking advanced computing portfolio, reflecting the growing and changing use of computation and data in both the research and education processes, and capable of supporting hundreds to thousands of investigators conducting cutting-edge S&E research; and
- **Coordination and Support Services**, which aims to coordinate the provisioning, allocation, and operations of NSF's advanced computing resources, providing advanced assistance to the user community, supporting aggregation and federation capabilities, enabling the translation of CI research advances, and broadening participation.

In FY 2024, NSF-funded advanced computing systems and services will support the full breadth of NSF-funded S&E, including research furthering our understanding of climate science and clean-energy technologies, notably (i) data-driven approaches to assimilate heterogeneous data sets about climatology; (ii) large-scale modeling of Earth systems; and (iii) high-end simulations of renewable and alternative energy approaches, and novel materials supporting energy efficiency and sustainability.

[7] www.rti.org/publication/national-cyberinfrastructure-coordination-service-conference
[8] www.nsf.gov/pubs/2020/nsf20015/nsf20015.jsp
[9] www.nsf.gov/cise/oac/datacirfi/rfi_responses.jsp
[10] www.rcac.purdue.edu/ciworkforce2020
[11] www.nsf.gov/cise/oac/vision/blueprint-2019/nsf-aci-blueprint-v10-508.pdf

Leadership-Class Computing

Description

Leadership-class computing systems have represented a key component of NSF's computational portfolio for decades. NSF's current leadership-class computing system is Frontera, which is deployed at the Texas Advanced Computing Center (TACC) at the University of Texas at Austin (UT Austin). Frontera is one of the most powerful supercomputers in the world and is the most powerful supercomputer ever deployed on a U.S. academic campus. The system began accepting early S&E research users in May 2019 and became fully operational in October 2019. Frontera is expected to allow researchers to tackle much larger and more complex S&E applications than ever before, within and across disciplines as diverse as biology, astronomy, engineering, materials science, and geosciences. The Frontera system offers the highest scale, throughput, and data analysis capabilities ever deployed on a U.S. university campus. In addition, Frontera's graphics processing unit (GPU) accelerates discoveries in important research areas such as deep learning and molecular dynamics.

Current Status

At its July 2018 meeting, the NSB authorized the Director to make a $60.0 million award to TACC for the acquisition of the Frontera system over a period of five years, the first acquisition in a two-phased process. The NSB, at its May 2019 meeting, also authorized the Director to make a $60.0 million award to TACC for the operations and maintenance (O&M) of Frontera over a period of five years. Frontera has been in operation since September 2019 and is actively used by the S&E research and education community across NSF and other agencies.

The July 2018 NSB resolution also authorized, pending appropriate approval associated with MREFC policies, supplemental funding to advance the design of a Phase 2 leadership-class computing facility (LCCF). In July 2019, TACC started the design and planning process for the LCCF (refer to the MREFC narrative on the LCCF for more information).

S&E Research and Education Activities Enabled by Leadership-Class Computing

Leadership-class computing systems enable investigators across the Nation to conduct innovative research that is not otherwise possible due to demanding computing requirements. In FY 2020, NSF issued a Dear Colleague Letter[12] describing a new innovative pilot mechanism for the Nation's researchers to request access to Frontera to enable scientific and engineering research that would not otherwise be possible without access to a leadership-class computing resource. To date, this effort has resulted in over 150 allocation awards to research teams across the country. Examples of research that was enabled by the Frontera allocation awards include the full-scale modeling of the entire hippocampus in the brain to understand neurological disorders; simulations of supermassive black hole mergers to enable future gravitational wave detection; some of the largest simulation in the world to understand the physics and conditions that cause the formation of severe tornados; and high-resolution seismic hazard modeling to improve the health and safety of the Nation's earthquake prone regions.

NSF-funded leadership-class computing education and outreach activities consist of projects targeting students at pre-college, undergraduate, graduate, and post-graduate levels; workshops, conferences, summer schools, and seminars; as well as industry partnership activities. These activities have

[12] www.nsf.gov/pubs/2020/nsf20018/nsf20018.jsp

enabled more than 200 education, outreach, and training projects at over 160 institutions, including institutions in the Established Program to Stimulate Competitive Research (EPSCoR) jurisdictions. An example of one of these activities is the Frontera Computational Science Fellowship program,[13] which provides a year-long opportunity for talented graduate students to compute on Frontera and collaborate with experts at TACC; this program awarded five fellowships in FY 2022.

Management and Oversight

The Frontera project is overseen by OAC's program directors and BFA's Division of Grants and Agreements staff, who receive strategic advice from the AD Council. Advice from the NSF Office of General Counsel is also sought, as necessary. The NSB receives updates on any major changes in risk assessments, which are reviewed annually by an external panel. Risks monitored during the operational phase of a project include system security, performance, reliability, usability, project management, and other factors that could reduce the overall scientific impact.

Advanced/Innovative Computing Systems and Services

Description

NSF funds the acquisition and operation of nationally available Advanced/Innovative Computing Systems and Services that, in aggregate, are forward-looking, connected, and technically diverse, and reflect changing and growing use of data-intensive computation in both the research and education processes. At the same time, they are intended to enable discoveries at a computational scale beyond the reach of an individual or regional academic institution.

Deployed systems currently serve as a cohesive set of resource providers allocable within the Coordination and Support Services described in the following section. Awards are made as two parts: an acquisition and deployment award, which may be the result of a competitive or a renewal proposal; and a separate award for O&M following deployment. When an award is made, the awardee institution issues subawards to vendors and/or other organizations for acquisitions and services, as necessary. Expenditures are contingent on successful completion of deployment milestones. These resources are also accessible via the Partnership to Advance Throughput Computing (PATh) project and includes PATh's national scale federated data sharing fabric called the Open Science Data Federation.[14]

Current Status

In FY 2016, NSF awarded *Stampede 2: The Next Generation of Petascale Computing for Science and Engineering* to TACC, enabling the acquisition and deployment of Stampede 2. Stampede 2 serves as the primary national resource for approximately 7,000 academic researchers, complements other national advanced computing systems and services, and provides capabilities beyond the reach of individual campuses and regional resources. Stampede 2 was fully deployed as a production resource by the end of 2018 and is expected to continue operations through December 2023. This includes technical upgrades awarded in FY 2021 and FY 2023 to extend operations, partially upgrade the processor architecture, reconfigure the deployed filesystem, and explore pilot high-throughput computing allocations via the PATh project.[14]

[13] www.frontera-portal.tacc.utexas.edu/fellowship/

[14] www.nsf.gov/awardsearch/showAward?AWD_ID=2030508

Beginning in FY 2019, NSF made a series of investments in advanced/innovative computing systems and services to foster an integrated CI ecosystem that addresses the growing scale and diversity of the S&E community, the changing nature of S&E research requirements, and the rapidly evolving technology and services landscape, with the overarching goal of supporting the full range of computational- and data-intensive research across all S&E domains. Specifically, NSF issued the *Advanced Computing Systems and Services (ACSS): Adapting to the Rapid Evolution of Science and Engineering Research* solicitation[15] in FY 2019, with the first cohort of three awards running from FY 2019 to FY 2025,[16] followed by a second cohort of five awards running from FY 2020 to FY 2026,[17] and a third cohort of 2 awards running from FY 2021 to FY 2026.[18]

The ACSS solicitation called for investments in two categories:

- Category I, Capacity Systems: production computational resources maximizing the capacity provided to support the broad range of computation and data analytics needs in S&E research; and
- Category II, Innovative Prototypes/Testbeds: innovative forward-looking capabilities deploying novel technologies, architectures, usage modes, etc., and exploring new target applications, methods, and paradigms for S&E discoveries.

The current active ACSS solicitation includes support for Category I investments in FY 2023 and FY 2025, and Category II investments in FY 2024 and FY 2026.[19]

The current suite of Category I systems includes:

- *Expanse*: Located at the San Diego Supercomputer Center (SDSC), this system is a large-capacity, data-focused system supporting increasingly diverse, complex, and expanding research across multiple S&E disciplines within the "long tail" of science. Expanse is expected to be operational through FY 2025.
- *Bridges 2*: Located at the Pittsburgh Supercomputing Center (PSC), this system integrates AI-based analytics capabilities with the technical capacity to execute data- and computationally intensive research in a broad, cross-cutting manner, enabling advances across a range of S&E research and education. Bridges 2 is currently expected to be operational through FY 2025.
- *Anvil*: Located at Purdue University, Anvil is a composable system with an expansive portfolio of S&E-focused interfaces, programming environments, and advanced capabilities to support research and education. Anvil is currently expected to be operational through FY 2026.
- *Delta*: Located at the University of Illinois Urbana-Champaign (UIUC), Delta is a large-capacity, balanced computational resource supporting traditional computational methods combined with rapidly evolving and expanding AI-based techniques and advanced data science methods to advance S&E research and education. Delta is expected to be operational through FY 2026.
- *Jetstream 2*: Located at Indiana University, Jetstream 2 provides a nationally distributed, large-capacity, cloud-enabled computational resource supporting diverse S&E-focused "on-demand" access modes and utilization models to be available across research and education. Jetstream 2 is currently expected to be operational through FY 2026.

[15] www.nsf.gov/funding/pgm_summ.jsp?pims_id=503148
[16] www.nsf.gov/pubs/2019/nsf19534/nsf19534.htm
[17] www.nsf.gov/pubs/2019/nsf19587/nsf19587.htm
[18] www.nsf.gov/pubs/2020/nsf20606/nsf20606.htm
[19] www.nsf.gov/pubs/2023/nsf23518/nsf23518.htm

In addition, the Category II, or Testbed-Prototype Systems, include:

- *Ookami*: Located at SUNY at Stony Brook, this prototype incorporates processors originally developed to lead Japanese national efforts[20] towards future computing to advance U.S.-based S&E research and education. Ookami is currently expected to be operational through FY 2025.
- *Neocortex*: Located at PSC, this prototype deploys a novel AI-focused processor architecture in a high-performing system design supporting very high-scale, complex analytics challenges across S&E research and education. Neocortex is currently expected to be operational through May 2026.
- *Voyager*: Located at SDSC, this prototype integrates AI/ML/deep learning-focused components to advance S&E research and education. Voyager is currently expected to be operational through May 2026.
- *National Research Platform (NRP):* Located at SDSC, with partners at University of Nebraska, Lincoln (UNL) and the Massachusetts Green High Performance Computing Center (MGHPCC), this prototype will deploy a distributed testbed architecture including high-performance subsystems supported by low-latency high-bandwidth research and education networking. The prototype NRP is currently expected to be operational through May 2026.
- *Accelerating Computing for Emerging Sciences (ACES)*: Located at Texas A&M University, this prototype system will deploy a novel composable system architecture with the flexibility to aggregate various components on an as-needed basis to solve problems previously not addressable by researchers. ACES is currently expected to be operational through September 2026.

During their respective operational periods, NSF will evaluate the utility of the above listed Category II, or Testbed-Prototype Systems and determine whether they can be integrated into the suite of production services.

S&E Research and Education Activities Enabled by Advanced/Innovative Computing Systems and Services

The ecosystem of advanced/innovative computing systems and services is enabling new, world-leading, and transformative advances across the breadth of S&E research, in the integration of research and education, and in broadening participation in S&E by underrepresented groups. It is enabling new collaborations across public and private sectors to advance the Nation's security and economic competitiveness. These advances are made possible by providing researchers and educators with access to world-leading computational systems and services beyond what is typically available on most campuses. Providing access includes providing the expertise, interfaces, consulting support, and training necessary to facilitate use of the systems and services. This activity is central to achieving the full potential of complementary investments by NSF, other federal agencies, and academic institutions in computing infrastructure across the Nation.

Management and Oversight

OAC's program directors provide direct oversight over all Advanced/Innovative Computing Systems and Services awards. Oversight is executed via the use of cooperative agreements that include management structures, milestones, spending authorization levels, and review schedules. Each awardee is responsible for the satisfactory completion of milestones prior to NSF authorization of spending. Formal reporting consists of quarterly and annual reports, which are reviewed by the program directors. Progress is assessed with the aid of annual external reviews. In addition, each

[20] www.r-ccs.riken.jp/en/fugaku/project

project is required to have a project execution plan.

Any activity of this nature and at this scale comes with a certain element of risk. The review process, conducted prior to award, analyzes the risks as presented in the proposal and identifies any additional risks that should be considered. During the award process, risks are identified and analyzed, and a mitigation plan is created and followed. One of the activities that are a part of the periodic NSF external reviews conducted by an external panel of experts, is to revisit and reassess the risk and make recommendations as deemed necessary. In the case of projects that involve an acquisition, project risks are generally substantially reduced after deployment. Thus, the pacing of the acquisitions and deployments for such projects provides balance in the overall risk portfolio for the program.

Milestone-driven reviews occur during the acquisition award, typically with an external review prior to deployment. Annual reviews, conducted by an external panel of expert reviewers and managed by OAC program directors, are performed during the operational phase of each project.

Coordination and Support Services

Description

NSF's investments in a fabric of coordination and support services add value to the NSF advanced/innovative computing systems and services by coordinating allocations and access to the systems and services, providing advanced assistance to the user community, and broadening participation. Activities funded within coordination and support services include two major foci: the Advanced Computing Coordination Ecosystem: Services and Support (ACCESS) suite of awards, and the Partnership to Advanced Throughput Computing (PATh).

The ACCESS shared services model for coherently and efficiently providing researchers with both access to and expertise for diverse, dynamic, and distributed resources is a cornerstone of the National advanced computing ecosystem; enabling the connection between individual campuses and national resources is an essential aspect.

ACCESS enables and supports leading-edge scientific discovery and promotes science and technology education. The program encourages innovation in the design and implementation of an effective, efficient, increasingly virtualized approach to the provisioning of high-end digital services, while ensuring that the infrastructure continues to deliver high-quality access for the many researchers and educators who use it in their work.

ACCESS shared services consist of several interrelated parts: allocation of resources to computational and data research projects; advanced user assistance; training, education, and outreach; architecture and operation of an integrated digital services infrastructure; metrics services; and overall coordination. These elements are designed and implemented in a way that is clearly tied to the requirements of the S&E research community, using a flexible methodology that permits the architecture to evolve in response to changing community needs and that presents individual users with a common environment regardless of where the resources or researchers are located.

For researchers requiring high-throughput computing, computing that can be characterized by executing large numbers of tasks over a long period of time, the PATh project makes Distributed High Throughput Computing (dHTC) capacity available to researchers through a fabric of services. These

services enable the federation of resources into an effective source of computing capacity for a wide spectrum of science applications. PATh supports single-PIs and collaborative science groups across science and engineering disciplines to join the cohort of international physical science collaborations who have leveraged the dHTC paradigm for decades.

Current Status

NSF outlined plans for a fabric of national CI coordination services in a blueprint document released in FY 2020.[21] This blueprint was based on findings from the NSTC FACE Subcommittee, guidance from ACCI and advisors, responses to an RFI, and feedback from engagement with the community about the structure and composition of future coordination efforts. Following the blueprint, NSF issued the *Advanced Cyberinfrastructure Coordination Ecosystem: Services & Support (ACCESS)* and *ACCESS - Coordination Office (ACCESS-ACO)* solicitations[22-23] in early FY 2021. Awards for ACCESS services and the ACCESS-ACO were made during FY 2022.

The ACCESS suite of awards includes:

- *Allocation Services (RAMPS)*: The ACCESS Resource Allocations Marketplace and Platform Services (RAMPS) project was awarded to Carnegie-Mellon University (CMU), with subawards to UIUC and the University Corporation for Atmospheric Research. RAMPS allocates the capacity of the resource providers supported by the Advanced/Innovative Computing Systems and Services.
- *End User Support Services (MATCH)*: The Multi-tier Assistance, Training, and Computational Help (MATCH) was awarded to the University of Colorado Boulder, with subawards to the MGHPCC and the Ohio State University. MATCH enables innovative research through equitable and scalable support services to end users.
- *Operations & Integration Services (CONECT)*: Core National Ecosystem for CyberinfrasTructure (CONECT) project was awarded to UIUC, with subawards to the University of Chicago and CMU. CONECT delivers innovative integrations across the suite of resource providers in the areas of operations, data and networking, and cybersecurity.
- *Monitoring & Measurement Services*: Awarded to SUNY at Buffalo, this award provides metrics services allowing measurement and monitoring of key operational data from the advanced computing/innovative systems and services portfolio.
- *ACCESS Coordination Office (OpenCI)*: Awarded to UIUC, with subawards to the University of California San Diego, and Georgia Tech, the OpenCI Coordination Office facilitates shared governance across the ACCESS awardees.

PATh is a five-year award to the University of Wisconsin-Madison. Within the award, six partners are engaged through sub-awards: Indiana University, Information Sciences Institute (USC), Morgridge Institute for Research, University of California San Diego, University of Chicago, and University of Nebraska-Lincoln. The award is now in its 2nd year.

Coordination and Support services prior to the ACCESS program were funded by the eXtreme Digital (XD) program, which included the eXtreme Science and Engineering Discovery Environment (XSEDE) project. The XSEDE project was extended through August 2022 and included a 6-month overlap period with ACCESS to provide a smooth transition to services with a new organizational structure with

[21] www.nsf.gov/cise/oac/vision/blueprint-2019/nsf-aci-blueprint-services.pdf
[22] www.nsf.gov/pubs/2021/nsf21555/nsf21555.htm
[23] www.nsf.gov/pubs/2021/nsf21556/nsf21556.htm?org=NSF

minimal disruption to the community. The XSEDE award will formally conclude in FY 2023.

S&E Research and Education Activities Enabled by Coordination and Support Services

Coordination and support services, as exemplified by the ACCESS and PATh awardees, enable transformative advances in S&E research, in the integration of research and education, and in broadening the participation of underrepresented groups in S&E. These advances are accomplished by providing researchers and educators with coherent and highly usable access to digital resources beyond those typically available on most campuses, together with the interfaces, consulting, advanced user support, and training necessary to facilitate their use.

Coordinated access to advanced/innovative computing systems and services enables researchers to efficiently manipulate, analyze, visualize, and share extremely large amounts of distributed digital information from simulations, sensors, and experiments. The coordination and support services awarded will enable the cyberinfrastructure ecosystem, including resources and CI professionals, to innovate and evolve in sync with S&E research and education needs and opportunities. External communication, outreach, and community-building efforts by the ACCESS awardees will broaden the participation of individuals and communities that have been underserved by the national CI ecosystem.

The fabric of coordination and support services for the advanced CI ecosystem deliver tools and democratized access for researchers seeking resources, such as those described above, but also enable scientific collaborations for geographically distributed teams. In doing so, these services facilitate dynamic access to digital resources and experimental testbeds within and across university campuses, as well as government laboratories. These services also support the integration of research software and data with CI resources. Human-in-the-loop expert services and widely available training materials reduce barriers to the use of advanced digital systems by the research and education communities, thereby promoting enhanced productivity. For example, the XSEDE platform provided the basis for coordination and resource allocation among the more than 40 members of the COVID-19 HPC Consortium, and the team continues to provide essential services to support end users.

Monitoring and measurement services collect multi-dimensional data on advanced CI ecosystem usage statistics, users, and the computing resources' performance. They have also deployed CI measurement and optimization tools, namely XDMoD (XD Metrics on Demand) and its open-source counterpart, Open XDMoD, which are in use worldwide for advanced CI monitoring and reporting in academia and industry. Ongoing investments in these tools will enable the exploration of novel usage modes for advanced/testbed computing systems, integration with data repositories, instrumentation, and network performance. The immediate users of these methods and tools are the providers of NSF-supported advanced computing systems and services. However, both the tools and the data are publicly available and used by researchers, academic research computing center administrators, federal agencies, and industry seeking to optimize performance and forecast capacity demand.

Management and Oversight

OAC's program directors oversee the advanced CI ecosystem services and support projects. Project management is supported by guidance from an external advisory board, service provider councils, and ongoing formal and informal engagement with stakeholder communities. OAC's oversight of projects includes participation in regular teleconferences with senior personnel of awardee teams, quarterly briefings, and regularly scheduled planning sessions such as the allocation requests review

meetings. Formal reporting consists of quarterly and annual reports, which are reviewed by the program directors. Progress is assessed with the aid of annual external reviews. Each award is managed under a cooperative agreement with tailored terms and conditions, including an approved Project Execution Plan detailing management structure, milestones, deliverables, risk management, reporting of spending levels over time, and a review schedule. Each awardee is responsible for the satisfactory completion of milestones prior to NSF authorization of spending.

The PATh award is actively managed through monthly project meetings, monthly reports, monthly updates on goals and milestones, quarterly reports, annual reports, and a Project Execution Plan that is updated at least once per year.

DIRECTORATE FOR ENGINEERING (ENG) $970,000,000

Directorate for Engineering (ENG) Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Chemical, Bioeng., Environm'l & Transport Systems (CBET)	$203.42	$203.45	-	$203.45	$214.99	$11.54	5.7%
Civil, Mechanical, & Manufacturing Innovation (CMMI)	239.28	239.30	-	239.30	252.87	13.57	5.7%
Electrical, Comms, and Cyber Systems (ECCS)	123.10	123.11	-	123.11	130.09	6.98	5.7%
Engineering Education & Centers (EEC)	132.55	134.07	-	134.07	156.23	22.16	16.5%
Emerging Frontiers & Multidisciplinary Activities (EFMA)	76.19	74.87	34.00	108.87	215.82	106.95	98.2%
Total	**$774.53**	**$774.80**	**$34.00**	**$808.80**	**$970.00**	**$161.20**	**19.9%**

[1] Excludes $45.37 in American Rescue Plan supplemental funding.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About ENG

In FY 2024, ENG will spur engineering breakthroughs to help ensure America's security, prosperity, health, and technological leadership in the future. ENG will invest in groundbreaking fundamental engineering research and in key Administration and NSF-wide research priorities. Substantial directorate investments—in cross NSF priority areas as well as the fourth generation of NSF Engineering Research Centers (ERCs)—will emphasize convergence research approaches to help address grand challenges and achieve societal impact. In addition, to advance U.S. global competitiveness, strategic ENG support will strengthen the engineering workforce and accelerate the translation of technological innovations.

To accelerate the translation of research results towards economic and societal benefits, ENG will build on its tradition of partnerships with industry and other government agencies and laboratories. Through the NSF-funded Engineering Research Visioning Alliance, engineers with broad perspectives identified key research directions in reports on *The Role of Engineering to Address Climate Change* (2022) and *Leveraging Biology to Power Engineering Impact* (2022).[1] The directorate supports both direct and indirect partnerships, such as the ERC, Industry–University Cooperative Research Centers (IUCRC), Grant Opportunities for Academic Liaison with Industry (GOALI) investments. Working with the TIP directorate, ENG will spur the engineering research community to follow existing well-established pathways towards technology translation and implementation. In addition, ENG will work closely with TIP to develop new translation pathways, building on and enhancing existing successes in our center programs (ERC and IUCRC). Research results from ENG's mid-size convergent research awards create new opportunities that are ripe for translational impact.

ENG funding in FY 2024 will help protect Americans through the continuation of its long-term support for engineering research to improve resilience to hurricanes, fires, earthquakes, and other disasters, including the Natural Hazards Engineering Research Infrastructure (NHERI). ENG will help secure and advance communications, computing, and sensing through investments in QIS-related programs for quantum technologies and systems. Other ENG-funded research will investigate methods and technologies for protecting the electric grid, understanding online influence and misinformation, detecting biological threats, and optimizing supply networks.

[1] www.ervacommunity.org/report-category/full-reports/

ENG FY 2024 investments will build future prosperity through essential contributions to research on advanced manufacturing, supply chains, biomanufacturing for health and other applications, and the circular economy; new materials and semiconductor technologies; and clean energy technologies and climate change adaptation and mitigation, including sustainable regional systems, innovations for decarbonization, and partnerships for clean energy challenges. The directorate will support advances in robotics, AI, and smart and autonomous systems. Building on prior FW-HTF research, ENG will introduce convergent research opportunities and themes on human-centered automation; behavioral, equity, economic, and regional drivers in the design and implementation of new technologies; human-machine teaming to advance understanding of the ways integrated workforce models and complement human cognitive capabilities; and other topics at the human-technology interface. ENG will also invest in disruptive technologies to advance spectrum-efficient advanced wireless systems and energy-efficient resilient microelectronics and computing. Funding across ENG will help ensure sustainable and reliable infrastructure systems through, for example, precision agriculture, complex models of food-energy-water systems, and eco-friendly disaster-resilient building materials and designs. Continued investments in partnerships and research infrastructure will provide researchers and students with access to testbeds, fabrication, and scale-up that speed technology translation.

ENG support will advance health technologies and systems through investment in fundamental research to observe nanoscale cellular processes and changes, engineering biology to reverse disease and produce therapies, and synthetic biology to advance a wide array of biotechnologies. The directorate also will support research on the transport of contaminants and pathogens in natural and built environments, methods to detect and monitor their presence, and the prevention and understanding of their impacts on the community and ecology. Engineering investments will continue advances in prosthetic and assistive technologies for veterans, senior citizens, and people with disabilities.

ENG will also emphasize support for racial equity and diversity efforts. ENG, together with other NSF directorates and offices, will invest in research, education, and workforce development that remove barriers, build capacity, and foster partnerships. ENG will continue investment in the Broadening Participation in Engineering program and the Engineering Research Initiation program, invest in mentoring and professional development activities, support collaborations with MSIs, and promote systemic changes that enhance diversity, equity, and inclusion in engineering.

While fundamental engineering research fuels U.S. technological innovation and competitiveness, ENG support for workforce development and innovation speeds and strengthens the translation of discoveries. The directorate will invest in research on engineering education, broadening participation, equity, and inclusion in engineering, as well as in student experiences with industry. ENG will maintain its commitment to talented students and faculty through programs supporting transitions between career stages and opportunities for mid-size, interdisciplinary team research. ENG investments in academic partnerships and professional development opportunities with industry will help bring new ideas from lab to market and fortify the Nation’s innovation ecosystem.

Major Investments

ENG Investments
(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Estimate Base Total[3] Amount	Change over FY 2023 Estimate Base Total[3] Percent
Advanced Manufacturing	$129.00	$125.00	$184.37	$59.37	47.5%
Advanced Wireless Research	26.00	25.00	27.75	2.75	11.0%
Artificial Intelligence	88.00	88.00	97.00	9.00	10.2%
Biotechnology	92.00	92.00	106.50	14.50	15.8%
Climate: Clean Energy Technology	150.00	193.00	229.75	36.75	19.0%
Climate: USGCRP	-	-	50.00	50.00	N/A
Improving Undergraduate STEM Ed.	-	5.00	6.65	1.65	33.0%
Microelectronics/Semiconductors	43.00	43.00	63.00	20.00	46.5%
National Nanotechnology Initiative	267.13	190.95	231.75	40.80	21.4%
Quantum Information Science	31.17	29.50	32.89	3.39	11.5%
Secure & Trustworthy Cyberspace	3.25	3.25	3.25	-	-

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate/office narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

To learn more about cross-agency themes and initiatives supported by ENG, including Advanced Wireless, Artificial Intelligence, Biotechnology, Climate, Quantum Information Science, Networking and Information Technology R&D, Secure and Trustworthy Computing, see individual narratives in the NSF-Wide Investments chapter.

- Advanced Manufacturing: With ENG leadership, NSF investments accelerate advances in manufacturing materials, technologies, and systems to create products and processes with higher performance, greater sustainability, and new capabilities, as well as prepare our manufacturing workforce. The Future Manufacturing program catalyzes new manufacturing capabilities that do not exist today. For more information, see the Advanced Manufacturing narrative in the NSF-Wide Investments chapter.
- Clean Energy Technology: With ENG leadership, NSF enables new understanding and innovations to support energy efficiency, enhance sustainability, adapt to and mitigate climate change, spawn new industries, and support translation and partnerships for innovation, as well as education and workforce development. For more information, see the Climate: Clean Energy Technology narrative in the NSF-Wide Investments chapter.
- Microelectronics/Semiconductors: With ENG leadership, NSF enables new paradigms in microelectronics and semiconductor capabilities. Activities advance materials, devices, circuits, architectures, and related software and applications. NSF invests in secure, sustainable, high-performance semiconductors; microelectronic device integration; R&D ecosystems; and workforce development. For more information, see the Microelectronics/Semiconductors narrative in the NSF-Wide Investments chapter.
- National Nanotechnology Initiative: With ENG leadership, NSF invests in the understanding, organization, manipulation, and control of matter at the atomic, molecular, and supramolecular levels in the size range of about 1 nanometer to 100 nanometers. An increased focus will be on nanotechnology as a foundation for other emerging technologies, as well as for mitigating climate

change and supporting vaccine development. For more information, see the NNI narrative in the NSF-Wide Investments chapter.

Centers Programs

ENG Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
AI Research Institutes (Multiple)	$1.00	$2.00	$4.00	$2.00	100.0%
Engineering Research Centers (EEC)	70.47	68.70	86.09	17.39	25.3%
STC: Sci. & Tech. for Phosphorus Sustainability Ctr. (CBET)	5.00	5.00	5.00	-	-
STC: Ctr. for Engineering Mechanobiology (CMMI)	5.00	5.00	5.00	-	-
Total	**$81.47**	**$80.70**	**$100.09**	**$19.39**	**24.0%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For Organization detail on the People Numbers and Funding Profile tables, please see the Technical Information chapter.

DIVISION OF CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, AND TRANSPORT SYSTEMS (CBET)

CBET Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$203.42**	**$203.45**	**$214.99**	**$11.54**	**5.7%**
Research	198.73	198.26	209.80	11.54	5.8%
Education	1.01	1.50	1.50	-	-
Infrastructure	3.68	3.69	3.69	-	-

[1] Excludes funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

CBET supports research and education to enhance and protect national health, energy, food, water, environment, manufacturing, and security, by investing in areas involving the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. Through CBET, the physical, chemical, and biological sciences are integrated in engineering research and education, leading to advances in biotechnology, bioengineering, biomanufacturing, advanced materials, environmental engineering, climate adaptation and mitigation, and sustainable clean energy. In general, about 84 percent of the division portfolio is available to support new research grants. The remaining 16 percent supports research grants made in prior years.

DIVISION OF CIVIL, MECHANICAL, AND MANUFACTURING INNOVATION (CMMI)

CMMI Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$239.28**	**$239.30**	**$252.87**	**$13.57**	**5.7%**
Research	218.74	221.65	229.62	7.97	3.6%
Education	2.56	2.95	2.95	-	-
Infrastructure	17.98	14.70	20.30	5.60	38.1%

[1] Excludes funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

CMMI funds fundamental research and education that advances civil, design, mechanical, industrial, systems, manufacturing, and materials engineering. In addition, the division has a focus on the reduction of risks and damage resulting from earthquakes, wind, and other hazards on the built environment and in the context of a socio-technical system. CMMI encourages discoveries enabled by cross-cutting technologies such as adaptive systems, artificial intelligence, robotics, nanotechnology, and high-performance computational modeling and simulation. In general, about 75 percent of the division portfolio is available to support new research grants. The remaining 25 percent supports research grants made in prior years.

DIVISION OF ELECTRICAL, COMMUNICATIONS, AND CYBER SYSTEMS (ECCS)

ECCS Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$123.10**	**$123.11**	**$130.09**	**$6.98**	**5.7%**
Research	117.09	116.87	123.85	6.98	6.0%
Education	0.57	0.90	0.90	-	-
Infrastructure	5.44	5.34	5.34	-	-

[1] Excludes funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

ECCS supports transformative research at the nano, micro, and macro scales that fuels impacts on quantum, cyber and wireless technologies, sensing, clean energy and power systems, healthcare, transportation, robotics, advanced manufacturing, and other systems-related areas. The division's programs encompass novel electronic, photonic, quantum, and magnetic devices, including energy-efficient, sustainable and secure semiconductors and microelectronics, and the integration of these devices into circuit and system environments, intelligent systems, control, and networks. In general, about 80 percent of the division portfolio is available to support new research grants. The remaining 20 percent supports research grants made in prior years.

DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC)

EEC Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$132.55**	**$134.07**	**$156.23**	**$22.16**	**16.5%**
Research	116.49	118.02	137.03	19.01	16.1%
Education	16.06	16.05	19.20	3.15	19.6%
Infrastructure	-	-	-	-	N/A

[1] Excludes funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

EEC invests in the creation of 21st century engineers and the discovery of new technologies through engineering education research, broadening participation in engineering, research and experiential learning opportunities for students and teachers, and transformational center-based research. EEC leads the signature ERC and IUCRC programs, which impact advanced manufacturing; biotechnology and health; agriculture; energy, sustainability, and infrastructure; and microelectronics, sensing, quantum, and information technology. In general, about 22 percent of the division portfolio is available to support new research grants. The remaining 78 percent supports research grants made in prior years.

OFFICE OF EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES (EFMA)

EFMA Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$76.19**	**$74.87**	**$34.00**	**$108.87**	**$215.82**	**106.95**	**98.2%**
Research	76.01	73.62	33.00	106.62	214.57	107.95	101.2%
Education	-	0.15	-	0.15	0.15	-	-
Infrastructure	0.18	1.10	1.00	2.10	1.10	-1.00	-47.6%

[1] Excludes funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

The EFMA office enables ENG to strategically pursue and support projects in important emerging areas. A central activity of EFMA is the Emerging Frontiers in Research and Innovation (EFRI) program, which funds interdisciplinary projects with potential for major impacts on national needs and/or grand challenges. EFMA also provides ENG with the necessary flexibility to invest in long-term challenges and to adapt as new challenges arise. In FY 2023, EFMA serves as steward of DRS funding for cross-NSF activities in Climate: Clean Energy Technology. In FY 2024, EFMA will invest in coordination hubs to catalyze partnerships for clean energy challenges; interdisciplinary research for extreme design in the age of climate change; and trailblazing engineering researchers for impacts on grand challenges. In general, about 83 percent of the office portfolio is available to support new research grants. The remaining 17 percent supports research grants made in prior years.

DIRECTORATE FOR GEOSCIENCES (GEO) **$1,236,380,000**

GEO Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Atmospheric and Geospace Sciences (AGS)	$288.17	$288.00	$5.89	$293.89	$318.61	$24.72	8.4%
Earth Sciences (EAR)	202.41	202.11	2.00	204.11	213.15	9.04	4.4%
Ocean Sciences (OCE)	418.81	417.05	16.43	433.48	447.43	13.95	3.2%
Research, Innovation, Synergies, and Education (RISE)	126.34	125.10	11.57	136.67	257.19	120.52	88.2%
Total	**$1,035.73**	**$1,032.26**	**$35.89**	**$1,068.15**	**$1,236.38**	**$168.23**	**15.7%**

[1] Excludes $40.69 in American Rescue Plan supplemental funding.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About GEO

GEO supports fundamental research that advances the frontiers of knowledge and drives technological innovation while improving our understanding of the many processes that create and sustain vital natural resources on which society depends. GEO is home to NSF's atmospheric and geospace, earth, and ocean research activities and provides coordination and administrative oversight to the Office of Polar Programs. GEO investigates diverse Earth system processes including space weather, the planet's water cycle, interactions across the land-ocean-atmosphere interface, the behavior of ice sheets, and geologic processes responsible for a variety of energy sources and strategic minerals. While individual investigators and small teams receive most awards, center scale activity, technology development, and facilities are all integral to the geosciences. This conjunction of approaches enables GEO to invest in compelling basic and use-inspired science that will underpin and enable the advances needed to assure our resilient future. Lives are saved, and property is preserved by better observing, understanding, and forecasting natural phenomena and environmental hazards such as earthquakes, tornadoes, drought, and solar storms.

GEO prioritizes interdisciplinary studies that contribute directly to national research priorities including resilience, equity, security, and economic prosperity. Resilience research and support of the U.S. Global Change Research Program (USGCRP) are areas of emphasis. Investments will focus on predictability and resilience of the Earth system, including abrupt environmental change and extreme events, the role of the oceans in mitigating climate change and as a sink of carbon dioxide, terrestrial-climate interactions, and water sustainability including the impacts and implications of drought and floods. The theme of resilience is utilized to advance social equity and building diverse and inclusive research ecosystems that focus on institutional transformation towards inclusivity.

Inherently observational, geoscience requires research tools and infrastructure to expand the knowledge frontier. Mid-scale research infrastructure in atmospheric, earth, and ocean science continues to be important to the advancement of these disciplines. Large scale research infrastructure, in addition to providing key observational and computational capabilities, offers opportunities for partnerships with international entities, other federal agencies, and other groups.

GEO's FY 2024 Request builds on past efforts and aligns strongly with NSF and national priorities. There are exciting emerging, maturing, and ongoing opportunities and research activities that, in

aggregate, meet important societal goals and transform the Nation's future. GEO investments prioritize:

- sustaining ongoing disciplinary and interdisciplinary research programs;
- supporting the highest quality research performed by individuals, groups, centers, and facilities;
- supporting early-career investigators;
- providing funding for targeted basic and use-inspired research in NSF-wide investments;
- increasing support for resilience and climate research;
- advancing innovation and partnerships to catalyze the path to a more resilient Earth; and
- promoting equity and broadening participation in STEM research.

GEO-funded research supports NSF's key investment themes: Create Opportunities Everywhere, Build a Resilient Planet, Strengthen Research Infrastructure, and Advance Emerging Industries for National and Economic Security.

Create Opportunities Everywhere: GEO will continue to explore ways to identify and address barriers to equity and participation in the geosciences. Efforts include enhancing the support of early-career researchers from a variety of institutions as well as ensuring support for postdoctoral fellows from groups underrepresented in GEO fields of study. In FY 2024, GEO will start a special initiative to support Climate Equity Fellows. This program will train students and researchers in science important for addressing climate change and to be knowledgeable about the disparate impacts of climate change on disadvantaged or underserved communities and to integrate these perspectives into the design of their research projects.

Build a Resilient Planet: In FY 2024, GEO will expand its activities related to risk and resilience. A new effort to build a comprehensive National Resilience Network program will focus on four key areas:

- improving disaster resilience in communities;
- developing technologies needed to advance resilience research;
- implementing a climate innovation challenge to determine the effectiveness, impact, and unintended consequences on proposed and already initiated climate interventions; and
- supporting research on the human health implications of climate change.

Strengthen Research Infrastructure: In FY 2024, GEO will invest in the continued operation and maintenance of major national facilities (see the Major Facility section of the Research Infrastructure Theme for more information). In addition, investments will address maintenance items in the academic research fleet and at the National Center for Atmospheric Research. FY 2024 will also see the initiation of ObsX; a program to develop next generation observing tools and technologies for deployment in and study of extreme environments.

Emerging Industries: In addition to supporting the Nation's need for supplies of the critical minerals that underpin the green revolution, GEO will continue investment in advanced Artificial Intelligence as well as Biotechnology tools and techniques.

Major Investments

GEO Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Estimate Base Total[3] Amount	Change over FY 2023 Estimate Base Total[3] Percent
Artificial Intelligence	$1.00	$5.00	$5.00	-	-
Biotechnology	10.00	10.00	10.00	-	-
Climate: USGCRP	337.60	355.60	479.46	123.86	34.8%
Climate Equity Fellows	-	-	15.00	15.00	N/A
GEO Access	-	-	8.00	8.00	N/A
National Resilience Research Network	-	-	47.50	47.50	N/A
ObsX	-	-	20.00	20.00	N/A
Postdotoral Research Fellowships	11.76	7.90	13.34	5.44	68.9%

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about the cross-agency themes and initiatives supported by GEO, such as Artificial Intelligence, Biotechnology, and USGCRP, see individual narratives in the NSF-Wide Investments chapter.

- Climate: USGCRP: GEO leads NSF efforts to support the goals of the USGCRP. Investments will focus on predictability and resilience of the Earth system, the role of the oceans in climate change, terrestrial-climate interactions, and water sustainability including drought and floods, and the intersection of natural, social, and built systems.

- Climate Equity Fellows: will support students and researchers to perform impactful climate change research, to be knowledgeable about the disparate impacts of climate change on disadvantaged or underserved communities, and to work to mitigate those impacts.

- GEO ACCESS: Accelerating Culture Change in the Earth & Space Sciences (GEO ACCESS), will build a network of regional-scale consortia focused on developing thriving graduate student cohorts, including the support needed to successfully navigate job and career opportunities.

- National Resilience Research Network: A resilient future can only be reached through novel solutions informed by the latest knowledge on the interactions between the natural, human, and built environments. GEO's vision for a National Resilience Network has four components:
  1. Disaster Resilient Communities: Awardees will work closely with local and regional communities to enhance understanding and develop the predictive capabilities needed for a more resilient future with a particular focus on the compounding effects of hazards and extreme events and how these events impact the economy and national security.

2. Tech to Resilience: New technologies are needed to advance understanding of Earth systems and advance clean energy technologies for regional and local adoption.
3. Climate Innovation Challenge: innovative science and detailed studies on the effectiveness, impact, and untended consequences on proposed and already initiated climate interventions.
4. Climate Change and Human Health: As global change intensifies due to human activity, identifying and understanding sources of danger, how the Earth systems work, the transport and alteration of chemical and geobiological species in the natural world, and other geologic processes is key to understanding corresponding changes in human health.

- ObsX: In FY 2024 GEO is forging a new partnership within NSF to create the next generation of observing tools and agile observing platforms. Born from the need to measure and observe in extreme environments (e.g. polar realms, under the seas, deep within the Earth's crust, in the air) the ObsX initiative will support fundamental research into methods, tools, and technologies that will enable large-scale, economical, and remote complex observations across systems and boundaries.

- Postdoctoral Fellowships: Postdoctoral research is a critical stage in preparation for professional careers. GEO is increasing support for programs to provide fellowships to about 20 additional postdoctoral researchers. These projects support fundamental research in important priority areas such as USGCRP, while also serving broader goals related to inclusivity in the science workforce.

Centers Programs

GEO Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
STC: Cntr for Learning the Earth w/ AI and Physics (AGS)	-	$5.00	$5.00	-	-
STC: Cntr for Chemical Currencies of a Microbial Planet (OCE)	5.00	5.00	5.00	-	-
Total	**$5.00**	**$10.00**	**$10.00**	**-**	**-**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

Major Facilities

GEO Funding for Major Facilities

(Dollars in Millions)

	Division	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
Academic Research Fleet (ARF)	OCE	$116.39	$127.11	$129.23	$2.12	1.7%
Arecibo Observatory	AGS	9.77	3.00	3.00	-	-
Geodetic Facility for the Advancement of GEoscience (GAGE)	EAR	12.75	13.25	13.82	0.57	4.3%
International Ocean Discovery Program (IODP)	OCE	51.70	50.40	52.77	2.37	4.7%
National Center for Atmospheric Research (NCAR)	AGS	104.64	116.20	134.41	18.21	15.7%
Ocean Observatories Initiative (OOI)	OCE	45.13	51.00	53.36	2.36	4.6%
Seismological Facility for the Advancement of GEoscience (SAGE)	EAR	21.00	22.50	23.49	0.99	4.4%
Total		**$361.38**	**$383.46**	**$410.08**	**$26.62**	**6.9%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual facilities, please see the Research Infrastructure section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For info on NSF's People Numbers and Funding Profile tables, please see the Summary Tables chapter.

DIVISION OF ATMOSPHERIC AND GEOSPACE SCIENCES (AGS)

AGS Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$288.17**	**$288.00**	**$5.89**	**$293.89**	**$318.61**	**$24.72**	**8.4%**
Research	135.26	143.05	-	143.05	143.74	0.69	0.5%
Education	4.01	3.14	-	3.14	4.68	1.54	49.0%
Infrastructure	148.90	141.81	5.89	147.70	170.19	22.49	15.2%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

AGS supports fundamental research that leads to improved understanding of the physics, chemistry, and dynamics of the Earth's atmosphere, weather, and climate as well as research and observations to discover how the sun interacts with the Earth's atmosphere and how the atmosphere interacts with other components of the Earth's integrated systems. Improved understanding drives state-of-the-science model development and predictability of weather, climate, and space weather events. AGS supports fundamental research and the infrastructure, facilities, and services that enable and support modern-day atmospheric and geospace research activities. AGS also enables education and workforce development activities that foster the success of early career scientists and grows a diverse world-class scientific and technical workforce. In general, about 34 percent of the division portfolio is available to support new research grants. The remaining 66 percent supports awards made in prior years.

DIVISION OF EARTH SCIENCES (EAR)

EAR Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$202.41**	**$202.11**	**$2.00**	**$204.11**	**$213.15**	**$9.04**	**4.4%**
Research	135.26	135.02	-	135.02	134.54	-0.48	-0.4%
Education	7.14	6.71	-	6.71	9.20	2.49	37.1%
Infrastructure	60.01	60.38	2.00	62.38	69.41	7.03	11.3%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

EAR supports fundamental research into the structure and composition of the Earth and the processes that govern it. Research spans the Earth from its surface to its center, and includes its evolution and history, and the life it has sustained over its four and a half billion years. This research

is critical for understanding Earth's environment and its impact on society, including its climate (past, present, future), the distribution of its natural resources (mineral, water, biota, and energy), and the fundamental drivers of geologic hazards. EAR research provides predictive and quantitative understanding of earthquakes, volcanic eruptions, floods, landslides, changing climate, natural resources, and the overall Earth System. EAR education and human resources engages a wide range of audiences in Earth Science research efforts and fosters a just, equitable, diverse, and inclusive culture across the geosciences. In general, about 45 percent of the division portfolio is available to support new research grants. The remaining 55 percent supports awards made in prior years.

DIVISION OF OCEAN SCIENCES (OCE)

OCE Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$418.81**	**$417.05**	**$16.43**	**$433.48**	**$447.43**	**$13.95**	**3.2%**
Research	178.11	185.84	-	185.84	186.11	0.27	0.1%
Education	10.76	9.13	-	9.13	10.96	1.83	20.0%
Infrastructure	229.94	222.08	16.43	238.51	250.36	11.85	5.0%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

OCE supports cutting-edge research, education, and infrastructure that advances the Nation’s scientific knowledge of the oceans to support the U.S. economy over the long term, provides vital information regarding national security matters such as sea-level rise, and advances U.S. leadership in ocean science and technological innovation. OCE is participating in the United Nations Decade of Ocean Science (2021-2030), through the U.S. National Committee for the Decade, to help ensure sustainable use of ocean resources and long-term ocean health. In general, about 26 percent of the division portfolio is available to support new research grants. The remaining 74 percent supports awards made in prior years.

DIVISION OF RESEARCH, INNOVATION, SYNERGIES, AND EDUCATION (RISE)

RISE Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$126.34**	**$125.10**	**$11.57**	**$136.67**	**$257.19**	**$120.52**	**88.2%**
Research	119.64	120.10	11.57	131.67	224.19	92.52	70.3%
Education	6.70	5.00	-	5.00	28.00	23.00	460.0%
Infrastructure	-	-	-	-	5.00	5.00	N/A

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

RISE supports novel, complex, or partnership projects in both research and education. These investments cut across traditional boundaries within the geosciences, encouraging interdisciplinary activities and responding directly to critical needs of the entire geoscience community. RISE's principal goals are to develop innovative means to initiate and support geoscience education, attract underrepresented groups to careers in the geosciences, foster the interchange of scientific information nationally and internationally, and join with other parts of NSF in major integrative research and education efforts. The division makes strategic investments in multidisciplinary research areas, international activities, education, diversity, and human resource development. The results of RISE investments will assist in ensuring that the United States has a well-educated and diverse workforce in the geosciences and in related technical fields such as resource exploration. In general, about 68 percent of the division portfolio is available to support new research grants. The remaining 32 percent supports awards made in prior years.

OFFICE OF POLAR PROGRAMS (OPP) **$565,600,000**

OPP Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Change over FY 2023 Base Total[1] Percent
Total	**$544.68**	**$545.16**	**-**	**$545.16**	**$565.60**	**$20.44**	**3.7%**
Research	110.78	115.61	-	115.61	106.82	-8.79	-7.6%
Education	3.71	3.92	-	3.92	3.93	0.01	0.3%
Infrastructure	430.19	425.63	-	425.63	454.85	29.22	6.9%
USALS	85.00	94.20	-	94.20	102.00	7.80	8.3%

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About OPP

OPP is the primary U.S. supporter of fundamental research in the polar regions. In the Arctic, NSF helps coordinate research planning as directed by the Arctic Research Policy Act of 1984, and the NSF Director chairs the Interagency Arctic Research Policy Committee (IARPC) created for this purpose. In the Antarctic, per Presidential Memorandum 6646, NSF manages all U.S. activities as a single, integrated program, making Antarctic research possible for scientists supported by NSF and by other U.S. agencies. The latter include the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, the Smithsonian Institution, the Department of Energy, and the National Institute of Standards and Technology. NSF's U.S. Antarctic Program (USAP) research activity also supports leadership by the U.S. Department of State in the governance of the continent and Southern Ocean under the aegis of the Antarctic Treaty System.

OPP invests in polar scientific research and education and provides research support and logistics, including infrastructure, such as permanent stations and temporary field camps in the Antarctic and the Arctic. OPP's FY 2024 Request is influenced by three key priorities: (1) maintaining strong research investments that provide the basis for cross-disciplinary system science; (2) supporting critical facilities that enable research in Earth's polar regions; and (3) the Antarctic Infrastructure Recapitalization (AIR) program (discussed in the MREFC portion of the Research Infrastructure theme). These priorities create opportunities to investigate the causes and future trajectory of environmental, biological, and human systems being observed in the polar regions that are tightly coupled to the global Earth system.

Beginning in FY 2020 and continuing through FY 2023, Antarctic field science, infrastructure construction, and Arctic field science were substantially deferred due to global pandemic travel restrictions and the need to manage the health and safety concerns in remote enclosed settings that have limited medical capacities. In FY 2024, OPP is planning for an increase in operating tempo relative to FY 2022-23, particularly in the Antarctic.

In addition to shared cross-directorate basic research objectives, OPP investments will be guided by

recent sponsored studies, as noted below, to identify priority areas and ensure effective polar research programs.

Highlights of OPP's activities and collaborations include:

- In FY 2024, OPP research funding is $106.82 million. To accommodate its core research priorities, OPP will continue to leverage intra-agency, interagency, and international partnerships.
- OPP will continue to support three Long-Term Ecological Research projects, two in the Antarctic and one in the Arctic, at $3.38 million.
- The Interagency Arctic Research Policy Committee (IARPC) five-year Arctic Research Plan,[1] released in December 2021, will continue to inform Arctic science investment priorities and efforts to build an integrated research capacity to address the opportunities and challenges of Arctic change for the Nation's security and economics and for the well-being of Arctic residents.
- Arctic research support and logistics funding is increased by $1.32 million to $75.32 million to support Arctic field science programs as the deployment tempo is anticipated to rise as travel restrictions are lifted. Also included in the increase is funding for deferred maintenance needs at Summit and Toolik Stations in Greenland and Alaska respectively.
- Research will continue as part of the Center for Oldest Ice Exploration (COLDEX) an NSF Science and Technology Center launched in FY 2021 with the goals of finding and studying the oldest possible ice core records of Earth's climate and environmental history, and to help make polar science more inclusive and diverse.
- In Greenland, OPP will fund and provide field support to the GreenDrill project which will sample bedrock under the ice sheet for evidence of ice-free conditions. The project will also collect data to inform models predicting ice sheet behavior, including disintegration, and sea-level rise.
- Two major land-based field seasons are being planned for the international Thwaites Glacier project in the FY 2024 season. This project, initiated in 2018, is jointly supported, including shared logistics, with the Natural Environment Research Council of the U.K. Fieldwork was largely suspended in FY 2021 and resumed with a marine cruise and some land-based work in FY 2022.
- Aligned with USGCRP, in FY 2024, OPP continues investment in the Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) project. SOCCOM is now an integral component of the Global Ocean Biogeochemical Array (GO-BGC), a global network of chemical and biological sensors used to monitor ocean health.
- In FY 2024 OPP will continue its investment in shipboard observations as part of the Arctic Observing Network program (AON) through support of two new AON projects, one in the Beaufort Sea and the other in the Davis Strait (between Greenland and Canada). These activities are supported by the Academic Research Fleet.
- In FY 2024 OPP will initiate a re-build of its aging Ice Core Facility located within the Denver Federal Center and managed by the U.S. Geological Survey. Construction will be completed in FY 2025. The facility stores and preserves ice cores sourced from polar and alpine environments. These cores are one of the most important high-resolution archives of past temperature and carbon dioxide change over the past million years and are critical for supporting climate change and USGCRP research.
- Education activities across OPP will continue to be supported through existing programs including Research Experiences for Undergraduates (REU) Supplements, REU sites, and other polar education activities.
- In FY 2024 OPP will continue to invest in cutting edge biotechnology and

[1] www.iarpccollaborations.org/uploads/cms/documents/final-arp-2022-2026-20211214.pdf

computational/bioinformatic cross-disciplinary studies to understand the interplay between future changes in the environment and the unique physical and genetic adaptations of polar organisms.

- To maintain U.S. leadership in the Southern Ocean marine science, OPP will invest $15.11 million in design studies of a future state-of-the-art ice-breaking research vessel.
- The U.S. Antarctic Logistical Support funding is increased by $7.80 million to $102.0 million. This will support field work in the Antarctic and reflects increases in heavy airlift flying hour rates, tanker and cargo ship charter rates, and bulk fuel prices.

In general, about 12 percent of the division portfolio is available to support new research grants. The remaining 88 percent supports awards made in prior years.

Major Investments

OPP Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Estimate Base Total[3] Amount	Change over FY 2023 Estimate Base Total[3] Percent
Biotechnology	$1.60	$1.60	$2.00	$0.40	25.0%
Climate: USGCRP[4]	236.00	197.26	197.26	-	-

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[4] FY 2022 Actual may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

To learn more about cross-agency themes and initiatives supported by OPP, such as Biotechnology and Climate: USGCRP, see individual narratives in the NSF-Wide Investments chapter.

OPP Funding for Centers Programs

OPP Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Change over FY 2023 Estimate Base Total[1] Percent
STC: Center for Oldest Ice Exploaration	$5.02	$5.00	$5.00	-	-

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

OPP Funding for Major Facilities

OPP Funding for Major Facilities

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
Geodetic Facility for the Advancement of GEoscience (GAGE)	$1.19	$1.30	$1.36	$0.06	4.6%
IceCube Neutrino Observatory (ICNO)	3.66	3.83	3.99	0.16	4.2%
Seismological Facility for the Advancement of GEoscience (SAGE)	0.87	0.87	0.91	0.04	4.6%
U.S. Antarctic Facilities and Operations (AFO)[2]	$244.67	237.14	256.66	19.52	8.2%
Total	**$250.39**	**$243.14**	**$262.92**	**$19.78**	**8.1%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[2] Includes development and design costs for the Antarctic Research Vessel of $7.44 million $12.43 million, and $15.11 million in FY 2022, FY 2023, and FY 2024, respectively.

For detailed information on individual facilities and construction projects, please see the Research Infrastructure section of the NSF-Wide Investments chapter.

People and Funding Profiles

For info on NSF's People Numbers and Funding Profile tables, please see the Summary Tables chapter.

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES (MPS) $1,835,790,000

MPS Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Astronomical Sciences (AST)	$283.61	$283.57	$8.76	-	$292.33	$303.33	$11.00	3.8%
Chemistry (CHE)	265.19	264.46	4.37	-	268.83	279.83	11.00	4.1%
Materials Research (DMR)	338.75	338.78	0.63	-	339.41	350.41	11.00	3.2%
Mathematical Sciences (DMS)	248.32	247.99	4.00	-	251.99	262.99	11.00	4.4%
Physics (PHY)	309.89	308.90	4.23	-	313.13	324.13	11.00	3.5%
Office of Strategic Initiatives (OSI)[3]	169.50	169.20	48.45	2.50	220.15	315.10	97.45	44.8%
Total	**$1,615.26**	**$1,612.90**	**$70.44**	**$2.50**	**$1,685.84**	**$1,835.79**	**$152.45**	**9.1%**

[1] Excludes $80.70 million in American Rescue Plan supplemental funding.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[3] Formerly titled Office of Multi-Disciplinary Activities (OMA)

About MPS

Research in the foundational physical sciences is the central theme of projects supported by MPS. The core areas of astronomical sciences, chemistry, materials research, mathematical sciences, and physics continue to advance and transform knowledge and support the development of the next generation of scientists. Sciences funded by MPS encompass an enormous range: from the smallest objects and shortest timescales studied to distances and timescales that are the size and age of the universe. MPS continues to foster and support interdisciplinary scientific programs that span in scope and complexity, ranging from individual investigator awards to large, multi-user facilities. Individual investigators and small teams receive most awards, but centers, institutes, and facilities are all integral and essential to MPS-funded research. This convergence of disciplines and various ways to organize researchers allows MPS to invest in advancing basic sciences that will underpin and enable innovations in the technologies of the future, enabling collaborations such as with the TIP Directorate, and help to support a strong U.S. economy for decades to come.

Through its centers and institutes programs, MPS will continue to support leading-edge science research and the development of the next generation of scientists engaged in research ranging from fundamental to translational science. MPS centers and institutes span a broad range of areas, from addressing challenges in fundamental mathematics to the development of advanced new materials.

Research tools and infrastructure are key priorities that MPS will continue funding. Mid-scale research infrastructure in astronomical sciences, chemistry, materials research, and physics continue to be important to the advancement of those disciplines. Large scale research infrastructure is also highly important and provides opportunities for partnerships with international entities, other federal agencies, and private foundations, as is evidenced by facilities such as the Atacama Large Millimeter/submillimeter Array, the Gemini Observatory, the National High Magnetic Field Laboratory, and the Large Hadron Collider (LHC). Construction activities began in April 2020 to upgrade the two primary LHC detectors, A Toroidal LHC Apparatus and the Compact Muon Solenoid, in preparation for high luminosity operation of the LHC. The Vera C. Rubin Observatory Project on the summit of Cerro Pachón in Chile is advancing the physical infrastructure available for astronomical sciences as well as

pioneering a state-of-the-art data management system and the largest digital camera ever constructed. The recently inaugurated Daniel K. Inouye Solar Telescope in Hawaii, the world's most powerful solar observatory, enables observation of our sun from the photosphere to the chromosphere, to the outermost corona, to better understand and predict phenomena like solar storms and space weather.

The MPS directorate's Request builds on past efforts and aligns with NSF's articulated FY 2024 priorities. There are exciting new opportunities emerging, research efforts that are maturing, and established programs and activities that continue to meet important goals and support science that will transform the Nation's future. The requested funding will enable MPS to sustain core research programs, supporting the highest priority centers, institutes, and facilities—including the design and development of future major facilities, and supporting early-career investigators. MPS will also enhance its investment in advancing emerging industries, such as quantum information science and engineering, advanced manufacturing, biotechnology, microelectronics, the spectrum innovation initiative, and artificial intelligence; continue support for climate research; increase support for clean energy technology; and increase support to promote equity and broadening participation in STEM research.

In FY 2024, MPS will continue support of the existing Quantum Leap Challenge Institutes and increase support for the Expanding Capacity in Quantum Information Science and Engineering program, which increases research capacity and broadens participation in QISE and enriches the talent and diversity in the workforce pipeline to help fulfill the needs of industry, government, and academia. In collaboration with other NSF directorates, including TIP, MPS will support a pilot phase program with the goal of establishing the National Quantum Virtual Laboratory (NQVL) as an overarching infrastructure platform designed to facilitate the translation of basic science and engineering to innovative technologies, while at the same time emphasizing and advancing the scientific and technical value of the research.

MPS will add a fellow-to-faculty component to the Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowship (MPS-Ascend) program to facilitate the transition of postdoctoral fellows to tenure track positions. The program will help broaden the participation in MPS fields among members of groups that have been historically excluded and are currently underrepresented. MPS will also increase its investment in the broadening participation partnership programs in all five of its research divisions.

At FY 2024 Request level and in support of the CHIPS and Science Act on research infrastructure, MPS will collaborate with other NSF directorates and offices, including OIA, to help establish the Revitalization of American Academic Research Infrastructure (RAARI) program to provide instrumentation and infrastructure support for emerging research institutions (ERIs) to address one of the major barriers ERIs encounter in recruiting and retaining faculty and involving students in cutting edge research.

Climate change and its impacts clearly represents one of the greatest challenges facing civilization today. MPS will support research in providing scientific modeling tools needed to advance our understanding of the physical basis of climate change and develop mitigation and adaptation solutions. MPS-supported research will also significantly contribute to innovation in clean and sustainable energy resources, creating solutions to problems that require fundamentally new ideas.

Major Investments

MPS Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual[3]	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Estimate Base Total[4] Amount	Change over FY 2023 Estimate Base Total[4] Percent
Advanced Manufacturing	$156.42	$128.33	$133.33	$5.00	3.9%
Advanced Wireless Research	17.00	17.00	17.00	-	-
Artificial Intelligence	134.18	75.21	84.20	8.99	12.0%
Biotechnology	75.63	62.20	62.20	-	-
Climate: Clean Energy Technology	123.08	123.83	123.57	-0.26	-0.2%
Climate: USGCRP	13.44	12.00	14.63	2.63	21.9%
Microelectronics/Semiconductors	50.96	31.00	33.00	2.00	6.5%
MPS Partnerships for Research and Education	9.73	12.50	32.50	20.00	160.0%
MPS Postdoctoral Fellowships	8.69	20.76	41.40	20.64	99.4%
Quantum information Science	229.87	179.00	214.00	35.00	19.6%
Secure & Trustworthy Cyberspace	1.27	1.25	1.25	-	-

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] FY 2022 Actual may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

[4] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about the cross-agency themes and initiatives supported by MPS, such as Advanced Manufacturing, Advanced Wireless, Artificial Intelligence, Biotechnology, Clean Energy Technology, USGCRP, Microelectronics/Semiconductors, and Secure and Trustworthy Cyberspace, see individual narratives in the NSF-Wide Investments chapter.

- Artificial Intelligence: MPS will strengthen its investments in AI and machine learning techniques for sciences, including establishing AI Institutes for Astronomical Sciences as well as initiating new research tools, such as Autonomous Laboratories and Digital Twins.

- Quantum Information Science: As steward of this program agency-wide, MPS will continue investment in the existing Quantum Leap Challenge Institutes and increase investment in the Expand QISE program. MPS will also support a pilot phase program with the goal of establishing the NQVL. For more information, see the QIS narrative in the NSF-Wide Investments chapter.

- MPS partnerships for Research and Education: MPS will increase investment in its broadening participation partnership programs across all five divisions.

- MPS Postdoctoral Fellowships: Postdoctoral research is a critical stage in preparation for professional careers. MPS will increase investment in its fellowship programs and add a fellow-to-faculty component to the MPS-Ascend program.

Centers Programs

MPS Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
Artificial Intelligence Research Institutes (MPS)	$6.14	$5.00	$13.00	$8.00	160.0%
Centers for Chemical Innovation (CHE)	27.46	27.70	27.70	-	-
Materials Centers (DMR)	53.27	56.80	57.00	0.20	0.4%
Quantum Leap Challenge Institutes (MPS)[2]	58.37	21.85	20.00	-1.85	-8.5%
STC: Center for Integrated Quantum Materials (DMR)[3]	3.73	-	-	-	N/A
STC: STC on Real-Time Functional Imaging (DMR)	5.00	5.00	5.00	-	-
STC: Center for Integration of Modern Optoelectronic Materials on Demand (DMR)	5.00	5.00	5.00	-	-
STC: Center for Bright Beams (PHY)	5.00	5.00	5.00	-	-
Spectrum Innovation Initiative Center (MPS)	5.75	5.00	5.00	-	-
Total	**$169.72**	**$131.35**	**$137.70**	**$6.35**	**4.8%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[2] Since FY 2020, Quantum Leap Challenge Institutes (QLCI) funding has been a vital source of NSF's overall $50 million investment in multidisciplinary centers for quantum research and education. The FY 2022 Actual is higher reflecting the forward funding of future award increments.

[3] This 2013 class STC received its final funding increment in FY 2022.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For info on NSF's People Numbers and Funding Profile tables, please see the Summary Tables chapter.

Major Facilities

MPS Funding for Major Facilities

(Dollars in Millions)

	Division	FY 2022 Actual	FY 2023 Estimate Base Total[1]	Disaster Relief Supplemental RI Damage Mitigation	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
Arecibo Observatory (AO)[2]	AST	$2.42	$3.00	-	$3.00	-	-
Green Bank Observatory (GBO)[3]	AST	15.53	10.83	-	9.55	-1.28	-11.8%
IceCube Neutrino Observatory	PHY	3.60	3.83	-	4.02	0.19	5.0%
Large Hadron Collider (LHC)	PHY	21.51	20.50	-	20.50	-	-
Laser Interferometer Gravitational-Wave Observatory (LIGO)	PHY	45.00	45.00	-	50.00	5.00	11.1%
National High Magnetic Field Laboratory (NHMFL)[3]	DMR	38.91	39.91	-	38.57	-1.34	-3.4%
National Radio Astronomy Observatory (NRAO)[3,4]	AST	102.71	93.66	-	98.35	4.69	5.0%
NRAO O&M[5]		52.09	43.03	-	43.59	0.56	1.3%
Atacama Large Millimeter Array (ALMA) O&M		50.63	50.63	-	54.76	4.13	8.2%
National Solar Observatory (NSO)[3]	AST	26.54	26.56	-	27.67	1.11	4.2%
NSO O&M		6.96	5.88	-	6.24	0.36	6.1%
Daniel K. Inouye Solar Telescope (DKIST) O&M		19.58	20.68	-	21.43	0.75	3.6%
NSF's National Optial-Infrared Astronomy Research Laboratory (NOIRLab)[3]	AST	56.39	73.57	2.50	82.21	8.64	11.7%
NOIRLab O&M (Mid-Scale Observatories & Community Science and Data Center)[6]		25.80	28.49	2.00	23.68	-4.81	-16.9%
Gemini Observatory O&M		25.38	22.98	0.50	24.73	1.75	7.6%
Vera C. Rubin Observatory O&M		5.20	22.10	-	33.80	11.70	52.9%
Total		**$312.62**	**$316.86**	**$2.50**	**$333.87**	**$17.01**	**5.4%**

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

[2] In FY 2024, NSF will transition from a cooperative agreement for operations of Arecibo Observatory to a contract for maintenance of the site.

[3] Funding in FY 2023 and FY 2024 does not include potential additional funding that may be provided by MPS' Office of Strategic Initiatives (formerly Office of Multidisciplinary Activities) for deferred maintenance projects.

[4] Incuded withiin NRAO's total funding is NSF's contribution to VLBA at $3.43 million per year.

[5] Includes funding for the ngVLA program office.

[6] Includes support for the Windows on the Universe Center for Astronomy Outreach, ongoing activities at the WIYN telescope, and potential future participation in the U.S. Extremely Large Telescope program.

For detailed information on individual facilities, please see the Research Infrastructure section of the NSF-Wide Investments chapter.

DIVISION OF ASTRONOMICAL SCIENCES (AST)

AST Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$283.61**	**$283.57**	**$8.76**	**$292.33**	**$303.33**	**$11.00**	**3.8%**
Research	63.71	72.52	-	72.52	78.78	6.26	8.6%
Education	3.67	4.60	-	4.60	4.60	-	-
Infrastructure	216.23	206.45	8.76	215.21	219.95	4.74	2.2%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

AST funds grants for astronomical research and provides access to world-class astronomical observing facilities via cooperative agreements. These observatories enable scientific advances by providing access on a competitive basis to thousands of astronomers each year. AST also supports the development of advanced technologies and instrumentation and manages the electromagnetic spectrum for scientific use by the entire NSF community. The AST portfolio includes research on the nature of planets, stars, galaxies, and the structure of the universe. Through collaboration with the Division of Physics, astrophysicists are able to probe the universe through three distinct "windows"—electromagnetic waves, high-energy particles, and gravitational waves—and across the time domain. This leads to a deeper understanding of the composition and evolution of the cosmos, including the nature of the mysterious dark matter and dark energy that comprise more than 95 percent of the universe. AST observatories and research programs have enabled the detection of planets orbiting other stars and will support the search for life on these other worlds.

In general, about 17 percent of the division portfolio is available to support new research grants. The remaining 83 percent supports research grants made in prior years.

DIVISION OF CHEMISTRY (CHE)

CHE Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$265.19**	**$264.46**	**$4.37**	**$268.83**	**$279.83**	**$11.00**	**4.1%**
Research	252.66	254.89	-	254.89	265.39	10.50	4.1%
Education	3.53	4.04	-	4.04	4.04	-	-
Infrastructure	9.00	5.53	4.37	9.90	10.40	0.50	5.1%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

CHE supports discovery research and workforce development in chemistry that have the potential to be transformative to major commercial sectors of the U.S. economy: energy, pharmaceuticals, medical applications, plastics, electronics, food, agriculture, and transportation. CHE investments also support highly competitive and rapidly evolving fields that include advanced manufacturing, quantum information sciences, data mining and artificial intelligence, sensor and instrument development, biotechnology, clean energy, sustainable chemistry, and climate research. Experimental, computational, and theoretical chemical research is integrated into core chemistry programs with a strong emphasis on sustainability and the protection of natural resources and environment. CHE encourages researchers to apply chemical understanding and tools to other fields, including biology, engineering, materials research, geosciences, mathematics/statistics, computing, and social sciences. Investments across fields not only expedite chemical understanding, innovation, and translation to market, but also have significant ramifications for the training and deployment of the future STEM workforce. The division uses multiple funding mechanisms to support individuals and team science as well as interdisciplinary user facilities.

In general, about 69 percent of the division portfolio is available to support new research grants. The remaining 31 percent supports research grants made in prior years.

DIVISION OF MATERIALS RESEARCH (DMR)

DMR Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$338.75**	**$338.78**	**$0.63**	**$339.41**	**$350.41**	**$11.00**	**3.2%**
Research	246.74	287.02	-	287.02	280.88	-6.14	-2.1%
Education	5.74	3.00	-	3.00	3.00	-	-
Infrastructure	86.27	48.76	0.63	49.39	66.53	17.14	34.7%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

Materials are ubiquitous and are the building blocks of technology and innovation. The development and deployment of advanced materials are major drivers of U.S. economic growth and essentially contribute to assuring national competitiveness and security. Materials research happens at the intersection of materials science and engineering with chemistry, physics, biology and mathematics. It directly and fundamentally impacts life and society, as it shapes our understanding of the world and enables critical advances in electronics, communications, transportation, and health-related fields. DMR invests in the discovery, prediction, design, and harnessing of new materials and materials phenomena, and in the development of the next generation of materials scientists. DMR creates a broad enterprise of investments across scales, including single investigators, teams, and centers; singularly focused research and areas requiring interdisciplinarity; and infrastructure ranging from small instruments to national mid- and large-scale user facilities. DMR investments are contributing to U.S. leadership in high-field magnet science and further aim at democratizing national access to high-magnetic fields. DMR also supports materials-relevant instrumentation and technique development broadly in x-ray and neutron science, nanofabrication, as well as automated and autonomous tools coupled to AI.

In general, about 26 percent of the division portfolio is available to support new research grants. The remaining 74 percent supports research grants made in prior years.

DIVISION OF MATHEMATICAL SCIENCES (DMS)

DMS Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$248.32**	**$247.99**	**$4.00**	**$251.99**	**$262.99**	**$11.00**	**4.4%**
Research	237.58	238.63	-	238.63	248.99	10.36	4.3%
Education	10.74	9.36	4.00	13.36	14.00	0.64	4.8%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

DMS provides the major federal support for research in the mathematical sciences. DMS investments support research at the forefront of fundamental, applied, and computational mathematics, and statistics that accelerates discovery and innovation. DMS partnerships with other science and engineering disciplines in turn inspire development of new theories and methods applicable to current and future national priority areas such as artificial intelligence, quantum information science, biotechnology, clean energy, and climate science. DMS prioritizes the development and advancement of future researchers in the mathematical sciences, through dedicated workforce programs, enhanced by broadening participation. DMS also supports institutes which advance mathematics and statistics research through thematic programs and workshops on current and emerging trends. DMS builds strong partnerships to expand the impact of its research investments. An example is the DMS partnership with SBE and BIO within NSF and NIH/NIDA to develop next generation epidemiological models to address the urgent need for reliable modeling tools to inform decision making and to evaluate public health policies during pandemics and other public health crises. DMS partners with private foundations such as the Simons Foundation on programs that support a variety of activities including the National Institute for Theory and Mathematics in Biology and research centers on the Mathematical and Scientific Foundations of Deep Learning.

In general, about 56 percent of the division portfolio is available to support new research grants. The remaining 44 percent supports research grants made in prior years.

DIVISION OF PHYSICS (PHY)

PHY Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$309.89**	**$308.90**	**$4.23**	**$313.13**	**$324.13**	**$11.00**	**3.5%**
Research	213.54	216.80	-	216.80	220.67	3.87	1.8%
Education	4.09	5.02	-	5.02	5.02	-	-
Infrastructure	92.25	87.08	4.23	91.31	98.44	7.13	7.8%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

PHY supports fundamental research addressing frontier areas of physics that lead to the understanding of the make-up of the universe, from the formation of stars and galaxies to the principles of life processes on Earth. This research covers a range of physics subfields: atomic, molecular and optical physics, elementary particle physics, gravitational physics, nuclear physics, particle astrophysics and cosmology, physics of living systems, plasma physics, and quantum information science. PHY is the primary supporter of all U.S. research in gravitational physics and the leading supporter of fundamental research in atomic, molecular and optical physics. PHY is a major partner with DOE in support of elementary particle physics, particle astrophysics, nuclear physics, and plasma physics. PHY also has the only U.S. program designed for the support of physics research in living systems. The development of the most advanced cutting-edge computational resources, innovative technology, and new instrumentation is a key part of physics research. Tools developed by the physics community continuously have major impacts in other scientific and engineering fields, allowing PHY to contribute significantly to emerging new technologies such as quantum information science and artificial intelligence.

In general, about 30 percent of the division portfolio is available to support new research grants. The remaining 70 percent supports research grants made in prior years.

OFFICE OF STRATEGIC INITIATIVES (OSI)

OSI Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$169.50**	**$169.20**	**$48.45**	**$2.50**	**$220.15**	**$315.10**	**$97.45**	**44.8%**
Research	152.30	143.66	5.54	-	149.20	177.47	28.27	18.9%
Education	1.43	10.00	-	-	10.00	30.00	20.00	200.0%
Infrastructure	15.77	15.54	42.91	2.50	60.95	107.63	49.18	84.1%

[1] Does not captured funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

The MPS Office of Multidisciplinary Activities (OMA) will be renamed the "Office of Strategic Initiatives" (OSI) to reflect the mission, activities, and portfolio of the office. In partnership with MPS divisions and programs, OSI strategically invests in research, education, and infrastructure to support novel and strategic projects that are not readily accommodated by traditional organizational structures and procedures. Funding will focus on strategic priority areas relevant to MPS. As the steward for QIS, OSI will work with all MPS divisions, BIO, EDU, ENG, CISE and OISE to promote convergent approaches to advance quantum science and technology. MPS is the steward for Windows on the Universe (WoU), supporting AST, PHY, and GEO/OPP in activities that bring together fundamental research in electromagnetic waves, high-energy particles, and gravitational waves; and grow the nation's multi-messenger astrophysics, engineering, and data science workforce. OSI will supplement facility funding related to deferred and major maintenance projects as well as design and development of next generation facilities. OSI will collaborate with all MPS divisions to support their investments in AI for sciences and the science of AI, clean energy, and climate science research. OSI is the steward for the Spectrum Innovation Initiative (SII), which promotes transformative use and management of the electromagnetic spectrum with a focus on dynamic and agile spectrum utilization, benefiting multiple research areas. OSI will foster broadening participation through the MPS-Ascend program and the Launching Early-Career Academic Pathways in the Mathematical and Physical Sciences program and continue to place high priority on the Alliances for Graduate Education and the Professoriate: Graduate Research Supplement program and the MPS Graduate Research Supplements to Veterans program.

In general, about 42 percent of the division portfolio is available to support new research grants. The remaining 58 percent supports research grants made in prior years.

DIRECTORATE FOR SOCIAL, BEHAVIORAL, AND ECONOMIC SCIENCES (SBE) $360,600,000

SBE Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Behavioral and Cognitive Sciences	$102.69	$102.70	$1.00	$103.70	$120.41	$16.71	16.1%
Social and Economic Sciences	104.11	104.12	1.00	105.12	121.83	16.71	15.9%
Nat'l Ctr. for Science & Engineering Statistics	56.50	56.51	22.38	78.89	90.24	11.35	14.4%
SBE Office of Multidisciplinary Activities	22.55	22.49	3.00	25.49	28.12	2.63	10.3%
Total	**$285.86**	**$285.82**	**$27.38**	**$313.20**	**$360.60**	**$47.40**	15.1%

[1] Excludes $124,580 in American Rescue Plan supplemental funding.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About SBE

SBE researchers examine fundamental questions about the dynamic abilities of humans, the strength and resilience of essential institutions, the creation of jobs and industries, national security and relations between nations, and finding new ways to improve quality of life for all Americans. SBE-supported research empowers America's private and public sectors to grow the economy, secure the homeland, improve the health and safety of American families, enhance equitable decision making, and increase the competitiveness of farms, offices, and factories across the Nation.

SBE strategically seeks opportunities to build a better future. One way it does this is by investing in a new and increasingly diverse, dynamic, and skilled generation of young researchers in support of NSF's goal to Create Opportunities Everywhere. SBE support for early career investigators, undergraduates, graduate students, and postdoctoral research fellowships trains and prepares young scholars to develop rigorous and effective new ways to capitalize on the increasing availability of massive amounts of data to advance knowledge about human behavior. SBE researchers, for example, will have increasing opportunity to use and combine data from surveys, administrative records, brain imaging, and biospecimens, as well as output from behavioral, environmental, and geographic sensors to help others learn about how to create opportunity and improve life outcomes.

SBE is also home to the National Center for Science and Engineering Statistics (NCSES). One of only 13 principal statistical agencies in the federal government, and it is the Nation's source for science and engineering information in a global context. NCSES collects, analyzes, and disseminates information on representation across the scientific enterprise; research and development; innovation; the science and engineering (S&E) workforce; the condition and progress of STEM; and U.S. competitiveness in science, engineering, technology, and research and development.

SBE's FY 2024 Request is shaped by three guiding principles:
Support fundamental research that advances key national priorities. The research emphases include enhancing national security and preparedness; understanding, mitigating, and adapting to climate and global change; strengthening American infrastructure; broadening participation in STEM; studying the causes of, impacts on, and practices for addressing inequity throughout society; creating new opportunities for populations adversely affected by change; empowering American innovation

through research in emerging industries such as artificial intelligence (AI) with a focus on worker productivity and well-being in a growing range of work environments, including emerging industries; reliability of information networks; and improving quality of life for communities across the country.

Support NCSES, the Nation's source for information on the science and engineering enterprise. Various initiatives, including the Evidence Act, focus on improving federal agency performance and the productivity of America's S&E enterprise as a whole. These efforts require our Nation to make more effective use of the types of data that NCSES collects, analyzes, and disseminates. Increased support for NCSES allows the Nation to be more informed, more effective, and more agile in converting America's incredible talent and ability into better educational outcomes, more opportunity, greater productivity, and higher rates of innovation in all areas of American life.

Support and advance cross-directorate activities that address urgent national challenges. Whether the topic is creating the new jobs and industries that will yield an economic recovery that helps everyone, increasing national security through tools that better identify new and emerging threats, improving community resilience by improving response to natural disasters and pandemics, protecting consumers and institutions against misinformation and other attacks on vital infrastructure, broadening opportunity, understanding the people involved is critical. SBE works with all of NSF and other agencies to support research that solves big problems by putting people first.

With an FY 2024 Request of $360.60 million, or 15.1 percent over the FY 2023 Estimate Base, SBE will maximize support in disciplinary and interdisciplinary programs that support Administration and NSF-wide priorities, including advanced manufacturing research, AI, and USGCRP research. Funding will also support building research capacity at under-resourced institutions and expanding the STEM talent pool through the Build and Broaden program. SBE will also support NCSES's expanding role in the federal statistical enterprise.

The FY 2024 Request includes continued support for investments that integrate the social, behavioral, and economic sciences into multi-directorate and multidisciplinary activities that address issues of major scientific, national, and societal importance. These include research related to Brain Research through Advancing Innovative Neurotechnologies, National AI Research Institutes; SaTC; digital assets research; and Dynamics of Integrated Socio-Environmental Systems (DISES).

In FY 2024, SBE will continue its support for early career investigators—Faculty Early Career Development (CAREER) awards; undergraduates—Research Experiences for Undergraduates (REU); graduate students—Doctoral Dissertation Research Improvement Grants (DDRIG); and postdoctoral research fellows through its SBE Postdoctoral Research Fellowships (SPRF) program.

SBE's FY 2024 Request includes increased support for NCSES to initiate new data collection efforts as well as continued implementation of the Standard Application Process and development and implementation of the National Secure Data Service demonstration project. Consistent with recent executive orders that highlight the importance of objective and trustworthy data, SBE support will help NCSES continue to expand data tools, implement data collections, and address requirements of the CHIPS and Science Act (P.L. 117-167) and the Foundations for Evidence-Based Policymaking Act (Evidence Act). SBE is also committed to supporting NSF's efforts to meet all Evidence Act requirements, including having NCSES's Director serve as the Foundation's Statistical Official.

Major Investments

SBE Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Base Total[3] Amount	Change over FY 2023 Base Total[3] Percent
Advanced Manufacturing	$0.50	$0.50	$3.50	$3.00	600.0%
Analytics for Equity	-	0.75	2.04	1.29	172.0%
Artificial Intelligence	17.74	16.92	19.59	2.67	15.8%
Biotechnology	1.68	1.50	1.50	-	-
Build and Broaden	8.01	8.00	18.06	10.06	125.8%
Digital Assets Research	-	-	8.00	8.00	N/A
Climate: USGCRP	19.92	20.00	25.14	5.14	25.7%
SBE Post-Doctoral Research Fellowships	3.04	6.00	9.00	3.00	50.0%
Secure & Trustworthy Cyberspace	4.00	4.00	4.00	-	-
Strengthening American Infrastructure	6.64	6.00	8.00	2.00	33.3%

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about cross-agency themes and initiatives supported by SBE, such as Advanced Manufacturing, Artificial Intelligence, Biotechnology, Climate: USGCRP, National Nanotechnology Initiative, Networking, and Information Technology R&D, Secure and Trustworthy Computing, and Create Opportunities Everywhere, see individual narratives in the NSF-Wide Investments chapter.

- Analytics for Equity ($2.04 million in SBE plus an additional $2.0 million in Integrative Activities/Evaluation and Capability Assessment for an NSF total of $4.04 million): SBE will increase support for the Analytics for Equity Initiative, which builds on the Evidence-Based Policymaking Act and E.O. 13985 by creating a new way to support social, behavioral, and economic sciences research that leverages federal data assets (ensuring privacy is protected and data are secure) and scientific advances in researching equity-related topics for greater public benefit.

- Build and Broaden (B2; $18.06 million): SBE will increase investments in an innovative program that supports research collaborations and partnerships between scholars at MSIs and other institutions or organizations. Projects that: 1) build capacity and enhance research productivity in the SBE sciences at MSIs; 2) provide researchers with new ways to diversify and sustain collaborations; 3) foster partnerships that strengthen career and research trajectories for MSI faculty; 4) broaden participation of underrepresented entities in STEM entrepreneurship and innovation; and 5) contribute to more innovative science by diversifying research and widening the STEM pathways.

- Digital Assets Research ($8.0 million): In FY 2024, SBE will steward, in partnership with CISE and TIP, transdisciplinary, multi-institution, and multi-sector research efforts in digital assets. This

work will explore the broad socio-technical foundational and use-inspired research on digital assets (e.g., Central Bank Digital Currencies, crypto-currencies, non-fungible tokens, etc.), including the benefits and risks of these technologies. NSF's efforts will be in alignment with the forthcoming National Strategy for Digital Assets R&D.

- SBE Postdoctoral Research Fellowship ($9.0 million): SBE will increase its commitment to SPRF that promotes fundamental research in the SBE sciences by providing opportunities for recent doctoral graduates to obtain additional training and research experience; targets the participation of underrepresented groups in STEM; and encourages doctoral scientists who are not yet in full-time positions to take advantage of the two-year fellowship to prepare for scientific careers in academia, industry, private sector, or government. FY 2024 funding will expand support for broadening participation with an emphasis on PIs from underrepresented groups, states, and institutions.

- Strengthening American Infrastructure ($8.0 million): SBE will increase its commitment to this investment that links experts on physical, computational, and material aspects of infrastructure design with scientists whose fundamental research explains how humans will—and will not—use infrastructure. This human-centered approach to infrastructure is a critical component to building better, smarter, and more cost-effective roads, electric grids, hospitals, and more. Improving infrastructure in these ways spurs private-sector innovation, grows the economy, and is essential to national competitiveness.

Centers Programs

SBE Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Percent
Artificial Intelligence Research Institutes (Multiple)	$1.02	$1.52	$1.52	-	-

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For detail on People Numbers and Funding Profile, please see the Summary Tables chapter.

DIVISION OF BEHAVIORAL AND COGNITIVE SCIENCES (BCS)

BCS Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Percent
Total	**$102.69**	**$102.70**	**$1.00**	**$103.70**	**$120.41**	**16.71**	**16.1%**
Research	97.24	97.76	1.00	98.76	115.47	16.71	16.9%
Education	0.84	0.44	-	0.44	0.44	-	-
Infrastructure	4.61	4.50	-	4.50	4.50	-	-

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

BCS supports fundamental research that examines the sources of the human condition and the character of thinking and behavior. Programs examine these issues at multiple levels, ranging from genetics and brain activity to social, cultural, and environmental contexts. BCS also manages infrastructure-related activities in Human Networks and Data Science, which seek to advance relevant analytical techniques and develop user-friendly, large-scale, next-generation data resources to improve quality of life for all Americans. These activities are complemented by active involvement in funding competitions and development of partnerships, inside and outside of government, which support collaborative and cross-disciplinary projects that increase understanding of the human brain, mind, and behavior. In general, about 78 percent of the BCS portfolio is available to support new research grants. The remaining 22 percent supports research grants made in prior years and the research infrastructure needed by this community.

DIVISION OF SOCIAL AND ECONOMIC SCIENCES (SES)

SES Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Percent
Total	**$104.11**	**$104.12**	**$1.00**	**$105.12**	**$121.83**	**16.71**	**15.9%**
Research	81.26	98.53	1.00	99.53	116.24	16.71	16.8%
Education	0.14	0.50	-	0.50	0.50	-	-
Infrastructure	22.71	5.09	-	5.09	5.09	-	-

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

SES is concerned with the growth of our Nation through the provision of goods, services, opportunities, and wellbeing. SES supports research on how people collectively live, work, and prosper in productive businesses and other organizations. Priority topics include: management tools, risk assessment, and planning; workforce measurement, training, and development; markets, competition, and the economy; social trends and demographics; security and preparedness;

accountable institutions and behaviors; the science of and the legal and regulatory aspects of innovation, technology, and science; the safety and trustworthiness of new technologies; as well as the statistics, modeling, and other methodologies that enable forward thinking research. In general, about 67 percent of the SES portfolio is available to support new research grants. The remaining 33 percent supports research grants made in prior years and the research infrastructure needed by this community.

SBE OFFICE OF MULTIDISCIPLINARY ACTIVITIES (SMA)

SMA Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Percent
Total	**$22.55**	**$22.49**	**$3.00**	**$25.49**	**$28.12**	**$2.63**	**10.3%**
Research	16.27	16.43	-	16.43	16.06	-0.37	-2.3%
Education	6.28	6.06	3.00	9.06	12.06	3.00	33.1%
Infrastructure	-	-	-	-	-	-	N/A

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

SMA provides a focal point for the range of activities that cut across SBE and NSF disciplinary boundaries. SMA supports efforts that seek to improve the scale and effectiveness of the scientific workforce. It supports REU Sites, the Ethical and Responsible Research (ER2) program, Analytics for Equity, and the SPRF program. In FY 2024, SMA will play a key role in several crosscutting NSF investments as well as interdisciplinary research and training, via activities such as the SPRF-Fundamental Research and BP tracks. As the lead directorate for managing the ER2 program, with support from other NSF directorates, SBE coordinates the Online Ethics Center for Engineering and Science award. While all SBE divisions pursue interdisciplinary work, SMA assists with seeding multidisciplinary activities for the future, such as leveraged and targeted co-funding directed towards national, NSF, and directorate priorities. In general, about 51 percent of the SMA portfolio is available to support new research grants. The remaining 49 percent supports research grants made in prior years.

NATIONAL CENTER FOR SCIENCE AND ENGINEERING STATISTICS

NCSES Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Percent
Total	**$56.50**	**$56.51**	**$22.38**	**$78.89**	**$90.24**	**11.35**	**14.4%**
Research	0.37	-	-	-	-	-	N/A
Education	-	-	-	-	-	-	N/A
Infrastructure	56.13	56.51	22.38	78.89	90.24	11.35	14.4%

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

NCSES is one of the federal government's thirteen principal statistical agencies with a mission to provide information regarding the S&E enterprise in a global context. NCSES provides policymakers, researchers, and the public high-quality data and analysis on R&D, innovation, the education of scientists and engineers, and the S&E workforce. NCSES also supports research; the education and training of researchers; statistical methodology and data quality improvement efforts; and information compilation and dissemination to meet the statistical and analytical needs of a diverse user community.

The FY 2024 Request of $90.24 supports NCSES's core data collection and analytic activities, including nationally representative surveys of U.S. investment in R&D, innovation, the education of scientists and engineers, and the science and engineering workforce, and preparation of the aforementioned reports. Funding also supports NCSES leadership of government-wide evidence building activities and initiatives such as continued management of the Standard Application Process portal for applying to access restricted-use data from statistical agencies and units, as well as informing the proposed National Secure Data Service (NSDS) through projects, including the CHIPS and Science Act authorized NSDS Demonstration Project that uses America's DataHub. A corresponding increase of four FTE and related funding, associated with the expanded data collection efforts, SAP, and NSDS, for NCSES is included for FY 2024 in this request. Additional details regarding this staffing increase, can be found in the Personnel, Compensation, and Benefits section of the Agency Operations and Award Management chapter.

DIRECTORATE FOR TECHNOLOGY, INNOVATION & PARTNERSHIPS (TIP) $1,185,630,000

TIP Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Technology Frontiers	-	$129.80	-	-	$129.80	$196.80	$67.00	51.6%
Innovation and Technology Ecosystems	78.22	149.00		200.00	349.00	490.00	341.00	228.9%
Translational Impacts	334.86	171.00	220.00	10.00	401.00	488.64	97.64	25.0%
Strategic Partnerships Office	-	0.20	-	-	0.20	10.19	9.99	4995.0%
Total	**$413.09**	**$450.00**	**$220.00**	**$210.00**	**$880.00**	**$1,185.63**	**$515.63**	**77.0%**

[1] Excludes $230,000 in American Rescue Plan supplemental funding.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About TIP

TIP advances key technology focus areas to address societal, economic, national, and geostrategic challenges and opportunities; accelerates the translation of research results from the lab to the market and society; and cultivates new education pathways leading to a diverse and skilled future technical workforce comprising researchers, practitioners, technicians, entrepreneurs, and educators. Building on NSF's longstanding leadership in science and engineering research and education, TIP serves as a crosscutting platform that leverages, energizes, and rapidly advances use-inspired research and innovation. Further, TIP opens new possibilities for research, innovation, and education by catalyzing strategic partnerships linking academia; industry, including startups and small businesses; federal, state, local, and tribal governments; nonprofits and philanthropic organizations; civil society; and communities of practice to cultivate 21st-century innovation ecosystems that give rise to future, high-wage, good-quality jobs and enhance the Nation's long-term competitiveness.

TIP collaborates with NSF's other directorates and offices as well as with other federal agencies and the private sector to advance use-inspired, solutions-oriented research and innovation in key technology focus areas (e.g., advanced materials, AI, biotechnology, clean energy technology, future manufacturing, next-generation networks and systems, microelectronics and semiconductors, and QIS), as specified in the CHIPS and Science Act of 2022. Through these investments, TIP addresses a dynamic range of societal, economic, national, and geostrategic challenges (e.g., climate change, equity, bioeconomy, supply-chain resilience), as further specified in the CHIPS and Science Act of 2022. For example, in collaboration with CISE and SBE, TIP will advance democracy-affirming technologies, enabling practical privacy solutions, as well as digital assets research and development. Of particular note, in FY 2024, TIP will continue support for the NSF Regional Innovation Engines (NSF Engines), catalyzing regional-scale innovation ecosystems throughout the U.S., particularly in those parts of the Nation that have not benefited from the technology and innovation booms of the last several decades. NSF Engines will harness the Nation's diverse science and technology research enterprise, regional-level resources, and untapped innovation potential to accelerate advances in critical and emerging technologies, grow our economy, address societal challenges, and advance national security and competitiveness.

TIP also accelerates the translation of fundamental science and engineering discoveries into innovative new technologies and solutions. TIP optimizes the NSF Lab-to-Market Platform, allowing

researchers to pursue additional prototyping, demonstration, and scale-up work, giving rise to the startups and small businesses that are leading to new markets and economies of scale. In addition, TIP is introducing new translational pathways, for example, facilitating the adoption of NSF-funded research results as secure open-source ecosystems, affording the U.S. a competitive advantage in technology development vis-à-vis the closed-box approaches that others may take. As part of these efforts, TIP will support the establishment and operation of testbeds to advance development, operation, integration, deployment, and demonstration of innovative key technology focus areas.

Equity is a fundamental design principle across TIP's portfolio, providing opportunities for everyone to engage in the Nation's R&D enterprise. For example, TIP will work with academia, state, local, and tribal governments, industry, and other educational partners to provide practical experiences to diverse learners at every stage of education, from first-time job seekers to experienced workers.

TIP Investments

(Dollars in Millions)

Area of Interest	FY 2022 Actual	FY 2023 Estimate Base Total[1]	Disaster Relief Supplemental CHIPS and Science	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Change over FY 2023 Estimate Base Total[1] Percent
Accelerating Public and Private Partnerships	-	$0.20	-	$10.19	$9.99	4995.0%
Accelerating Research Translation	-	45.00	-	45.00	-	-
Assessment of Science and Technology Investments	4.00	20.00	-	25.00	5.00	25.0%
Convergence Accelerator	64.98	70.00	-	100.00	30.00	42.9%
Experiential Learning for Emerging and Novel Technologies	-	20.00	-	50.00	30.00	150.0%
NSF Entrepreneurial Fellows	2.24	-	10.00	10.00	10.00	N/A
NSF Lab-to-Market Platform:					-	N/A
PFI	30.04	30.00	-	30.00	-	-
I-Corps™	39.93	50.00	-	50.00	-	-
SBIR/STTR, including Operations	235.68	266.54	-	304.18	37.64	14.1%
Pathways to enable Open-Source Ecosystems	9.29	27.80	-	35.00	7.20	25.9%
Testbeds	-	-	-	106.00	106.00	N/A

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

- Accelerating Public and Private Partnerships: TIP, through SPO, will provide co-funding to incentivize the scale-up of strategic, high-impact public and private partnerships that will in turn deepen and advance NSF's mission across all areas of science, engineering, and education. TIP-enabled partnerships will also nurture talent by focusing on the engagement of populations long underrepresented in STEM, along with broad organizational changes in higher education and the inclusion of diverse institution types such as minority-serving institutions and community colleges.
- Accelerating Research Translation (ART): In alignment with the CHIPS and Science Act of 2022, TIP will support institutions of higher education that wish to build infrastructure needed to boost their institutional capacity to accelerate the pace and scale of translational research. ART will nurture a network of ambassadors who will champion translational research throughout the Nation.
- Assessments for Science & Technology Investments: TIP will continue to invest in long-term assessments of emerging technologies and industries to examine the alignment of federal science and technology research spending and programs with long-term U.S. competitiveness in these areas. As part of this assessment, TIP will conduct regular reviews evaluating the effectiveness of major federal R&D spending, and whether it is optimized for advancing U.S. competitiveness.
- Convergence Accelerator: TIP will regionalize the Convergence Accelerator, initiating investment

in regional anchors and teams pursuing technology solutions to pressing location-specific challenges including, but not limited to, food and agriculture, disaster response and mitigation, equitable water resources, and transportation. These efforts will leverage foundational advances by other NSF directorates and offices, nurture transdisciplinary and multi-sector teams that include industry, nonprofits, and others, and accelerate use-inspired research and innovation.

- Experiential Learning for Emerging and Novel Technologies (ExLENT): TIP will scale efforts to support inclusive experiential learning opportunities designed to provide cohorts of diverse learners with the crucial skills needed to succeed in key technology focus areas and prepare them to enter the workforce ready to solve the Nation's most pressing societal, economic, national, and geostrategic challenges. ExLENT will specifically promote cross-sector partnerships among companies, governments, and nonprofits, enabling learners at all levels and from all backgrounds, including adults interested in re-skilling and/or upskilling, to pivot into key technology focus areas. A particular focus of ExLENT will be to align the Nation's workforce with regional economies.
- NSF Entrepreneurial Fellows: TIP investment will allow Ph.D.-trained scientists and engineers to forge connections between academic research and government, industry, and finance as they mature promising ideas and technologies from the lab to the market and society.
- NSF Lab-to-Market Platform: TIP will optimize NSF's lab-to-market approach. Specifically:
    - Partnerships for Innovation (PFI): Provides NSF-funded researchers the opportunity to enter into partnerships to accelerate the transition of discoveries from the laboratory to the marketplace. In addition to supporting prototyping, technology demonstration, and scale-up work, including licensing of NSF-funded research outputs, PFI will grow its support for patent expenses for intellectual property reduced to practice.
    - NSF Innovation Corps (I-Corps™): Through a network of Hubs, I-Corps™ connects federally-funded science and engineering research with the technological, entrepreneurial, and business communities, linking scientific and engineering discovery with technology development, societal needs, and economic opportunities. I-Corps™ reduces the time and risk associated with translating promising ideas and technologies from the laboratory to the marketplace through entrepreneurial education including customer discovery.
    - SBIR/STTR: Provides the opportunity for startups and small businesses to undertake cutting-edge, high-quality scientific research and development to determine the scientific and technical feasibility of new concepts or innovations that could be developed into new products, processes, or services for profound societal and/or economic impacts. TIP will pilot a FastTrack option to accelerate the translation of deep technologies to the market.
- Importantly, beyond the Lab-to-Market Platform, TIP will introduce new translational pathways to enable the full breadth of socioeconomic impact for NSF-funded fundamental research. For example, in FY 2024, NSF will continue the recently-initiated Pathways to enable Open-Source Ecosystems (POSE) program, growing the number of secure open-source ecosystems resulting from fundamental research results.
- Testbeds: TIP will invest in the establishment and operation of testbeds to advance development, operation, integration, deployment, and demonstration of innovative critical technologies. These will serve as prototyping platforms that will allow experimentation across key technology areas.

Major Investments

TIP Funding for NSF-Wide Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	Disaster Relief Supplemental CHIPS and Science	FY 2024 Request	Change over FY 2023 Estimate Base Total[3] Amount	Percent
Advanced Manufacturing	$54.00	$41.60	$13.04	$73.60	$32.00	76.9%
Advanced Wireless	30.00	23.26	7.29	41.16	17.90	77.0%
Artificial Intelligence	100.00	78.09	24.48	138.19	60.10	77.0%
Biotechnology	30.00	52.58	16.48	93.05	40.47	77.0%
Climate: Clean Energy Technology	49.20	53.07	12.52	70.69	17.62	33.2%
Microelectronics/Semiconductors	15.00	38.25	11.99	67.68	29.43	76.9%
Quantum information Science	25.00	29.25	9.18	51.76	22.51	77.0%

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about cross-agency themes and initiatives supported by TIP, such as Advanced Manufacturing, Advanced Wireless, Artificial Intelligence, Biotechnology, Climate: Clean Energy Technology, Microelectronics/Semiconductors, and Quantum Information Science, see individual narratives in the NSF-Wide Investments chapter.

Centers Programs

TIP Funding for Centers Programs

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	Disaster Relief Supplemental CHIPS and Science	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Percent
NSF Regional Innovation Engines (NSF Engines)(ITE)	-	-	$200.00	$300.00	$300.00	N/A

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For info on NSF's People Numbers and Funding Profile tables, please see the Summary Tables chapter.

TIP Funding Mechanisms

NSF's award funding is used primarily for financial assistance to carry out a public purpose through grants and cooperative agreements. Grants can be either standard awards, in which funding for the full duration of the project is awarded in a single fiscal year, or continuing awards, in which funding for a multi-year project is awarded in increments. Cooperative agreements are used when the project requires substantial agency involvement (such as research centers and major facilities). Contracts are generally used for the direct benefit of the federal government (i.e., to acquire products or services), but they may be used to benefit the public in specific circumstances. NSF has had long-standing authority to use "other arrangements," and in FY 2022, NSF received "other transaction authorities" as part of the CHIPS and Science Act. These two mechanisms may support innovative approaches to fund programs managed by the TIP Directorate.

DIVISION OF TECHNOLOGY FRONTIERS (TF)

TF Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Percent
Total	**-**	**$129.80**	**-**	**$129.80**	**$196.80**	**67.00**	**51.6%**
Research	-	119.80	-	119.80	169.30	49.50	41.3%
Education	-	10.00	-	10.00	27.50	17.50	175.0%

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

TF accelerates breakthroughs in the key technology focus areas to sustain and grow U.S. competitiveness and security. These investments spur high-priority innovations in advanced materials, AI, biotechnology, clean energy technology, future manufacturing, next-generation networks and systems, microelectronics and semiconductors, and QIS, among other areas specified in the CHIPS and Science Act of 2022. As part of this investment, TF will advance democracy-affirming technologies, including privacy-preserving technologies, and digital assets research and development, in collaboration with CISE and SBE. TF additionally focuses on nurturing diverse talent by harnessing the innovative spirit that permeates all corners of our country, engaging individuals of all backgrounds, organizational affiliations, and geographic locations, thereby ensuring sustained leadership for generations to come.

To achieve the above outcomes, TF will partner with the other TIP units, other NSF directorates and offices, and other agencies, private industry, philanthropy, state and local governments, civil society, and investors. Specifically, TF pursues innovative partnerships and collaborations across sectors, along with transformative mechanisms such as testbeds to accelerate research activities and scale outputs and impacts.

Finally, TF will lead the assessment of key technology focus areas to examine the alignment of federal science and technology research spending and programs with long-term U.S. competitiveness in these

areas. Relatedly, TF will conduct regular reviews evaluating the implementation of major federal R&D spending, and whether that implementation is optimized for advancing U.S. competitiveness.

DIVISION OF INNOVATION AND TECHNOLOGY ECOSYSTEMS (ITE)

ITE Funding

(Dollars in Millions)

			Disaster Relief Supplemental					
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$78.22**	**$149.00**	**-**	**$200.00**	**$349.00**	**$490.00**	**$341.00**	**228.9%**
Research	78.12	139.00	-	200.00	339.00	467.50	328.50	236.3%
Education	-	10.00	-	-	10.00	22.50	12.50	125.0%
Infrastructure	0.10	-	-	-	-	-	-	N/A

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

ITE significantly strengthens the unique U.S. innovation ecosystem, engaging a broad, diverse set of individuals and organizations spanning government, academia, industry, philanthropy, civil society, and investors in the Nation's research, innovation, and education enterprise. ITE specifically brings together researchers, practitioners, and users to catalyze iterative co-design and co-creation, developing breakthrough technologies and addressing societal challenges. In this way, ITE enhances U.S. competitiveness and paves the way for new, high-wage, good-quality jobs.

Among its investments, ITE supports efforts that accelerate use-inspired, convergent research in areas aligned with Administration and Congressional priorities, including those articulated in the CHIPS and Science Act of 2022. For example, building upon a strong portfolio, the Convergence Accelerator will regionalize its approach, investing in cohorts of transdisciplinary, multi-sector teams pursuing technology solutions to location-specific challenges in food and agriculture, disaster response and mitigation, and transportation, to name a few. The NSF Engines will create regional-scale innovation ecosystems throughout the U.S. and usher in a transformational revolution of economic growth by harnessing the Nation's rich science and technology research enterprise and regional-level resources to accelerate key technology focus areas and address societal, economic, national, and geostrategic challenges. The NSF Engines will catalyze new business and economic growth especially in those regions of America that have not fully participated in the technology boom of the past several decades.

ITE also seeks to develop inclusive workforce-training pathways for the innovation-driven jobs of the future. For example, through ExLENT, ITE connects a highly diverse set of aspiring students and professionals interested in key technology focus areas with internship opportunities across the country, providing them with much-needed experience to land high-wage, good-quality jobs.

DIVISION OF TRANSLATIONAL IMPACTS (TI)

TI Funding

(Dollars in Millions)

			Disaster Relief Supplemental					
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$334.86**	**$171.00**	**$220.00**	**$10.00**	**$401.00**	**$488.64**	**97.64**	**25.0%**
Research	332.62	171.00	220.00	-	391.00	428.64	37.64	9.6%
Education	2.24	-	-	10.00	10.00	60.00	60.00	N/A

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriations.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

TI investments accelerate the translation of scientific excellence and technological innovation from the laboratory to society. By investing federal funds in a portfolio of universities, startups, small businesses, and open-source communities, TI stimulates the creation of novel products, services, and solutions that grow the national economy; catalyzes public-private partnerships that increase the depth and relevance of research activities; and nurtures and grows the US workforce, especially by fostering and encouraging participation by socially- and economically-disadvantaged individuals and groups.

In particular, TI provides an optimized Lab-to-Market Platform comprising the PFI, I-Corps™, and SBIR/STTR programs. TI additionally supports new pathways for translation, impacting government services, policy making, and education. For example, through the relatively new POSE program, TI facilitates the creation and growth of sustainable, high-impact collaborative environments that produce tools and products designed to be publicly accessible, modifiable, and distributable by anyone at no cost. Benefiting communities far beyond the initial applications, the resulting open-source ecosystems are expected to catalyze broad adoption across academia, industry, government, non-profits, and other sectors, and result in a growing, civic-minded community of users and developers.

TI also supports entrepreneurial education through the NSF Entrepreneurial Fellowships authorized in the CHIPS and Science Act of 2022. These fellowships provide Ph.D.-trained scientists and engineers with resources, including lab space, to mature promising ideas and technologies from lab to market. Along the way, the NSF Entrepreneurial Fellows become leaders in technology translation.

Finally, TI fosters cultural change within institutions of higher education, supporting the adoption of use-inspired research, translational research, and entrepreneurial training. For example, in partnership with ITE, TI invests in the ART program, which grows capacity for institutions of higher education to accelerate translational research, all the while supporting the requisite workforce development via mentorship and educational activities.

STRATEGIC PARTNERSHIPS Office (SPO)

SPO

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[1] Amount	Change over FY 2023 Base Total[1] Percent
Total	**-**	**0.20**	**-**	**0.20**	**10.19**	**9.99**	**4995.0%**
Research	-	0.20	-	0.20	10.19	9.99	4995.0%

[1] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

SPO serves as an agency-wide resource to catalyze and scale public and private partnerships in order to amplify and further the impact of NSF investments in research, innovation, and education. Specifically, SPO provides expertise and support to build partnerships, along with co-funding to strategically advance high-impact relationships that will deepen and advance NSF's mission across science, engineering, and education. SPO assists these partnerships in expanding the reach of, and exponentially increasing the return on, NSF's investments across its directorates and offices.

NSF's partnerships unite broad and diverse communities and coalitions in the pursuit of discovery and innovation by leveraging unique experiences and strengths of government, industry, academia, philanthropy, civil society, and investors to motivate the understanding of research problems and iteratively pilot research-based solutions through co-design. In addition to advancing the Nation's research enterprise, SPO-facilitated partnerships nurture STEM talent by focusing on the engagement of populations long underrepresented in or underserved by STEM, along with the inclusion of diverse organization types such as minority-serving institutions and community colleges. SPO also advances testbeds and other infrastructure critical to furthering the research and education enterprise, as authorized in the CHIPS and Science Act of 2022.

OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING (OISE) **$71,210,000**

OISE Funding

(Dollars in Millions)

FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
$54.23	$61.32	$8.00	$69.32	$71.21	$1.89	2.7%

[1] Excludes funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About OISE

OISE is the focal point for NSF's international science and engineering activities and promotes an integrated Foundation-wide international engagement strategy. The Office manages and coordinates catalytic internationally-focused programs, and advances international activities that offer opportunities for U.S. researchers through active engagement and outreach with international counterparts. This FY 2024 budget submission continues focus on three activities: (1) facilitating and supporting international teams and partnerships, (2) providing opportunities for the U.S. to shape the global science and engineering agenda, and (3) promoting the development of a globally engaged U.S. workforce.

In FY 2024, OISE will continue its investments in key priority areas like, building a resilient planet that includes climate science and clean energy technology research, and innovations in critical and emerging technologies for national and economic security through investments in cross-directorate collaborative efforts. Moreover, OISE's proposed FY 2024 investments will continue to promote the advancement of the research enterprise, ensuring accessibility and inclusivity, and securing global leadership. Within the framework of OISE's FY 2024 Request, the Office endeavors to preserve investments in its unique programs while maintaining cooperative investments through cross-directorate activities in Administration and agency priority areas to enable innovative international connections not otherwise possible for U.S. researchers and students.

OISE FY 2024 Activities

In FY 2024, OISE will continue its investment in the Global Centers (GC) activity to support larger-scale collaborative research on use-inspired themes related to grand societal challenges. In FY 2023, OISE launched the GC activity and released its inaugural solicitation to enable interdisciplinary and international teams to address grand societal challenges through use-inspired research. The FY 2023 competition focuses on topics related to climate research and clean energy research through GC-related partnerships with like-minded international counterpart funding agencies. This multi-lateral program encourages international research teams to seek additional partners from multiple sectors in the U.S. and abroad to leverage financial contributions and augment team capabilities. The GCs will facilitate the education and development of a globally-engaged workforce to support the climate and clean energy disciplines.

In FY 2024, OISE will continue its support for the Accelerating Research through International Networks (AccelNet) program. The goals of AccelNet are to accelerate the process of scientific discovery and prepare the next generation of U.S. researchers for multi-team international collaborations. AccelNet supports strategic linkages among U.S. research networks and complementary networks abroad (i.e., network of networks) to leverage research and educational resources to tackle grand scientific challenges aligned with Administration and agency priorities and that require significant coordinated international efforts. The program seeks to foster high-impact science and engineering by providing opportunities to create new collaborations and new combinations of resources and ideas among linked global networks. Each AccelNet award will build a network of networks across international and interdisciplinary boundaries. AccelNet will provide the funding to connect U.S. research networks with their international counterpart networks. These efforts will ensure the United States has access to the best ideas, people, and facilities, wherever they may be.

In FY 2024, OISE will continue to provide opportunities for U.S. STEM undergraduate and graduate students to participate in international research through the International Research Experiences for Students (IRES) program. The long-term goal of IRES is to enhance U.S. leadership by developing the next generation of STEM leaders. IRES supports the development of a diverse, globally-engaged U.S. science and engineering workforce and the active engagement of U.S. students in international research in all disciplines funded by NSF. In FY 2024, OISE will continue investments in two tracks:

- Track I supports international research experiences for cohorts of U.S. undergraduate and graduate students at international labs and research sites under the mentorship of host country scientists; and
- Track II supports advanced studies institutes that engage U.S. graduate students in active learning at the frontiers of knowledge with leading international experts.

The Global Venture Fund (GVF) resources new awards and supplements that include international collaborations, as well as projects which broaden participation by lowering barriers to international research. GVF funding augments programs resourced by the Research and Education Directorates. In FY 2024, OISE will continue its support for collaborative research that will enable innovative international connections not otherwise possible for U.S. researchers and students, advance the frontiers of knowledge, and contribute to U.S. scientific leadership.

In FY 2024, OISE will contribute to the following NSF cross-foundational activities.

- OISE will continue its support for Advanced Manufacturing at a level up to $500,000 to increase knowledge in emerging areas to enable a new generation of manufacturing industries that do not exist today, that are compatible with human needs, that make U.S. manufacturing competitive far into the future, and that builds in resilience to global disruptions for the Nation's manufacturing infrastructure.
- OISE will continue to fund NNA at a level up to $500,000. OISE's funds will support research that builds on and extends existing observing networks and scientific knowledge as well as logistics expertise to address the convergent scientific challenges in the changing Arctic. Interagency, state government, and international partnerships will be further developed to achieve pan-Arctic and Arctic-global perspectives.
- OISE will continue its investment of $1.0 million in QIS to promote international cooperation. QIS will continue to build upon and extend the existing knowledge of the quantum world, fostering breakthroughs in the fundamental understanding of quantum phenomena and enabling the exploitation of these phenomena to disrupt the Nation's science and engineering landscape.

These advances will unleash the potential of the Nation's quantum-based scientific enterprise, economy, and propel the Nation forward as a leading developer of quantum technology.

Major Investments

OISE Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request	Change over FY 2023 Estimate Base Total[3] Amount	Change over FY 2023 Estimate Base Total[3] Percent
Advanced Manufacturing	$0.20	$0.50	$0.50	-	-
Climate: Clean Energy Technnology	17.05	5.00	12.50	7.50	150.0%
Climate: USGCRP	12.00	13.00	12.50	-0.50	-3.8%
Quantum Information Science	-	1.00	1.00	-	-

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this office's support for selected areas of investment. In other directorate/office narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about cross-agency themes and initiatives supported by OISE, such as Advanced Manufacturing, Clean Energy Technology, USGCRP, and Quantum Information Science, see the individual narratives in the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For detail on the People Numbers and Funding Profile, please see the Summary Tables chapter.

INTEGRATIVE ACTIVITIES (IA) $646,370,000

IA Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request REVISED	Change over FY 2023 Base Total[2] Amount	Percent
EPSCoR[2]	$215.06	$205.00	$50.00	$255.00	$280.68	$25.68	10.1%
Equity and Compliance in Research	-	5.00	-	5.00	5.00	-	-
Evaluation & Assessment Capability	6.63	7.00	-	7.00	10.00	3.00	43%
Facility Operations Transition	-	-	-	-	12.00	12.00	N/A
Growing Convergence Research	16.86	16.00	-	16.00	16.43	0.43	3%
Growing Research Access for Nationally Transformative Equity & Diversity (GRANTED)[2]	-	34.18	10.82	45.00	50.00	5.00	11%
HBCU Excellence in Research	18.52	10.00	15.00	25.00	37.93	12.93	52%
Major Research Instrumentation[2]	78.01	63.75	20.00	83.75	92.75	9.00	11%
Mid-scale Research Infrastructure[2]	40.00	40.00	15.00	55.00	50.00	-5.00	-9%
Modeling and Forecasting	1.51	3.00	-	3.00	3.00	-	-
Planning & Policy Support	4.40	3.00	3.00	6.00	6.00	-	-
Research Investment Communications	5.46	1.30	4.70	6.00	6.50	0.50	8%
Research Security Strategy and Policy	1.27	10.00	-	10.00	13.00	3.00	30%
STC Class of 2023	-	-	24.00	24.00	24.00	-	-
STC Admin	0.60	0.60	-	0.60	0.60	-	-
Science & Technology Policy Institute	4.98	1.00	4.68	5.68	5.81	0.13	2%
Strategic Initiatives Resources[2]	-	[10.0]	[20.0]	[30.0]	32.67	[2.67]	N/A
Total	**$393.30**	**$399.83**	**$147.20**	**$547.03**	**$646.37**	**$99.34**	**18.2%**

[1] Excludes $35.33 million in American Rescue Plan Supplemental funding.

[2] FY 2023 funding includes one-time funding through the Strategic Initiatives line for targeted investments for EPSCoR co-funding ($10.0 million), GRANTED

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About IA

IA investments catalyze transformative advances in science and technology by incubating new ideas and communities, supporting innovation in research and in NSF's own processes, and promoting the integration of research and education. They enhance the competitiveness of the Nation's research through activities that build capacity for science and engineering (S&E) and broaden participation in research and research training, especially along organizational and geographic axes. They expand NSF's capacity to generate and use evidence for developing strategy and decision making.

IA invests in strategic activities that span the disciplinary spectrum, incubates new cross-cutting activities, and explores emerging ideas. IA provides a flexible mechanism to support emerging program priorities, including equity and compliance in research, research security, and effective communications about NSF's research investments. Sustained strategic investments include instrumentation, infrastructure, and cross-cutting collaborative research.

IA provides funding for innovative programs designed to enhance the ability of jurisdictions, institutions, and individuals to conduct globally competitive research. IA's jurisdictional and institutional capacity-building programs include Established Program to Stimulate Competitive

Research (EPSCoR), Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED), Historically Black Colleges and Universities - Excellence in Research (HBCU-EiR), and Major Research Instrumentation (MRI). The Alan T. Waterman honorary award recognizes and invests in emerging talent. IA also supports Science and Technology Centers: Integrative Partnerships (STC), a program that promotes discovery and innovation through center-scale collaborative research and knowledge transfer.

IA promotes and supports the use of evidence in NSF decision making, leads strategic planning for evidence-building activities, compiles data and statistics on key NSF processes, and conducts or oversees studies of NSF programs and other activities to guide continuous improvements.

IA FY 2024 Activities

Established Program to Stimulate Competitive Research (EPSCoR)

- EPSCoR investments assist NSF in its statutory function "to strengthen research and education in the sciences and engineering, including independent research by individuals, throughout the United States, and to avoid undue concentration of such research and education."
- EPSCoR provides strategic programs and opportunities that stimulate sustainable improvements to EPSCoR jurisdictions' R&D capacity and capability. EPSCoR aims to stimulate research that enhances jurisdictional competitiveness in NSF disciplinary and multidisciplinary research programs, especially those that drive economic growth.
- At the FY 2024 Request level, increased funding will support capacity building efforts to expand research partnerships in critical fields, such as quantum information science and engineering, biotechnology, and artificial intelligence. Additionally, FY 2024 funding increases will support advancement of interjurisdictional research and development capacity across different institution types.

Equity and Compliance in Research

- In FY 2024, NSF will continue to support its ability to maximize program delivery in an equitable manner, to include strategic planning and implementation, training, stakeholder engagement, complaint processing and investigation, partnership and international engagement, proactive compliance and recruitment and outreach activities. These activities respond to the need to address inequities in program delivery, Sexual Assault/Harassment Prevention & Response (SAHPR)[1] related concerns and requirements in executive orders (EO) (e.g., EO 14035 on Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce;[2] EO 13985 on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government;[3] and EO 14020 on Establishment of the White House Gender Policy Council[4]) and are informed by NSF's Racial Equity Task Force Report.

Evaluation and Assessment Capability (EAC)

[1] www.nsf.gov/geo/opp/documents/USAP%20SAHPR%20Report.pdf

[2] www.whitehouse.gov/briefing-room/presidential-actions/2021/06/25/executive-order-on-diversity-equity-inclusion-and-accessibility-in-the-federal-workforce/

[3] www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/

[4] www.whitehouse.gov/briefing-room/presidential-actions/2021/03/08/executive-order-on-establishment-of-the-white-house-gender-policy-council/

- EAC engages in strategic planning of evidence-building activities in support of the Agency's mission. This includes leading the development of the Agency's learning agenda, annual evaluation plan, inventory and analysis of evidence-building activities, and other activities that support the generation and use of evidence for decision making. Furthermore, EAC oversees or conducts evidence-building activities—including evaluations, foundational fact-finding, policy analysis, and other types of studies and analyses—in response to questions prioritized in the Agency's learning agenda, in the annual evaluation plan, or by leadership and staff in response to emerging needs.
- At the FY 2024 Request level, funding will support studies prioritized in the Agency-wide learning agenda and focused on enabling program improvements. This funding enables EAC to provide needed Agency-wide support that complements the work conducted by NSF directorates and offices. In partnership with other agencies, the FY 2024 Request includes support for the Analytics for Equity initiative.

Facility Operation Transition

- Facility Operation Transition reflects NSF's strategic commitment to a smooth transition from MREFC to O&M funding of new major facilities, as well as achievement of a balanced portfolio between facilities and investigator research, both of which were emphasized in the NSB's Congressionally requested 2019 report entitled "Study of Operations and Maintenance Costs for NSF Facilities" (NSB-2018-17).[5] The Facility Operation Transition funding will be used to (1) partially support initial O&M of new facilities so that the full O&M costs can be gradually absorbed into the managing division or directorate, and (2) partially support divestment of lower-priority facilities, the full cost of which may significantly impact individual division or directorate funding. For more information see the Facilities Overview narrative in the Major Facilities section of the Research Infrastructure chapter.

Growing Convergence Research (GCR)

- GCR supports innovative basic research that falls outside traditional disciplines and uses novel, transdisciplinary approaches to solve complex problems. Key project characteristics are: (1) they have the potential to make a significant impact, either on fundamental understanding in S&E or on the Nation's ability to meet pressing societal challenges, or both; and (2) they require the deep integration of knowledge, tools, and ways of thinking from across multiple disciplines. GCR also grows the next generation of convergence researchers. GCR incubates the capacity of research teams to address pressing, emerging research challenges that are large in scope, innovative in character, originate outside of any particular NSF directorate, and may require a multi-year commitment. In FY 2024, GCR investments will support three to seven new research collaborations and the continuation of three to six projects begun in FY 2022.

Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED)

- In FY 2024, NSF will invest in GRANTED, which is designed to lead to improvements in the Nation's research enterprise, including external funding support and service capacity and capabilities, especially within emerging and underserved research institutions. GRANTED funding will aim to mitigate the barriers to competitiveness at underserved institutions, including minority-serving institutions and emerging research institutions, within the Nation's research enterprise as NSF contributes to the Administration's priority on equity. GRANTED activities will support the

[5] www.nsf.gov/pubs/2018/nsb201817/nsb201817.pdf

enhancement of research administration and post-award management, the strengthening of the structure of research enterprise positions and career pathways, improved skill training, sharing and scaling of research enterprise practices and models, and expansion of partnerships between and across institutions and organizations that support research enterprise services. GRANTED will also partner with national and regional professional societies to grow the Nation's research capacity within underserved communities and institutions.

Historically Black Colleges and Universities – Excellence in Research (HBCU-EiR)

- The HBCU-EiR program focuses on improving the research capacity and competitiveness of HBCUs by supporting new research opportunities at these institutions. In FY 2024, investments in HBCU-EiR will fund 40 to 75 HBCU-EiR research grants managed by NSF research and education directorates. NSF will provide supplemental support to HBCU-EiR research activities involving postdoctoral researchers, graduate and undergraduate students. Additionally, HBCU-EiR will support funding mechanisms to enhance institutional research capacity and competitiveness, which may also include providing co-funding to NSF directorates in support of meritorious STEM research and STEM education research proposals from HBCUs.

Major Research Instrumentation (MRI)

- MRI invests in shared-use S&E research instrumentation as well as equipment and instrumentation to conserve or reduce the consumption of helium. Approximately 75 new awards will support instrument and equipment development and acquisition in all of NSF's S&E domains. MRI's investments also contribute to research-intensive learning environments that enhance the training of a diverse S&E workforce and facilitate partnerships between academia and the private sector.

Mid-scale Research Infrastructure Track-1 (Mid-scale RI-1)

- The Mid-scale RI-1 activity funded through the IA budget within the R&RA account is one component of NSF's Mid-scale Research Infrastructure program. It aims to significantly advance the Nation's capabilities for conducting potentially transformative research and maintaining U.S. leadership in global S&E. Mid-scale RI-1 investments support: (1) the implementation of research infrastructure projects between $4.0 million and $20.0 million; and (2) the design of future mid-scale research infrastructure projects. In FY 2024, Mid-scale RI-1 will invest $50.0 million in projects emerging from the FY 2023 competition.

Modeling and Forecasting

- NSF will improve its enterprise analytics capability in support of advancing research, improving equity in science, and securing global leadership. NSF will expand its capacity to leverage modeling of internal and external data to generate timely and actionable insights to inform agency strategy, investments, and programmatic decisions. NSF will harness big data (both structured and unstructured), data science (including AI techniques such as machine learning), and statistical modeling to advance portfolio analysis, monitor program participation, promote partnerships, and understand the outcomes of NSF's investments to advance scientific discovery and achieve societal goals. Results of this work will provide valuable information to promote excellence in achieving NSF's mission.

Planning and Policy Support (PPS)

- PPS includes funding for a wide range of activities, many of which are focused on generating

evidence and convening stakeholders in support of planning, policy development, and management efficiencies. Examples include conducting NSF surveys of principal investigators and reviewers, supporting studies of NSF's merit review process, strengthening enterprise analytics capability, engaging in annual agency award activities (such as the Alan T. Waterman Award and National Medal of Science), and supporting summer science internship programs that target STEM students from underrepresented groups. PPS also provides funding to support collaborations with the National Academies of Science, Engineering, and Medicine (the National Academies) for the Committee on Science, Engineering, Medicine, and Public Policy (CoSEMPuP)[6]; the Federal Demonstration Partnership[7]; and studies, workshops, and letter reports spanning multiple research domains. In FY 2024, PPS will continue to invest in catalytic activities—workshops, conferences, and long-term planning exercises, focused on emerging themes and agency innovations—as well as capacity-building activities for national priorities. PPS will invest in advancing public engagement in STEM visioning and in catalyzing research on robust indicators of rigor in research.

Research Investment Communications (RIC)

- RIC invests in leading-edge communication essential to build public and stakeholder awareness and support for S&E. RIC creates products and processes through various digital platforms to make NSF's investments in STEM readily available and easily understandable to everyone. In FY 2024, RIC informs policy makers, stakeholders, the media, and the general public about the impact of NSF's investments on their daily lives and the Nation's future.

Research Security Strategy and Policy

- In FY 2024, NSF will continue expanding capabilities and competencies to protect the U.S. science and engineering enterprise through its Research Security Strategy and Policy activity. Major components and activities of NSF's Research Security portfolio implemented and available by FY 2024 include: developing a common framework for understanding research security within the U.S. research community and with international colleagues; in partnership with other federal research agencies, establishing uniform mechanisms for research investigators to provide consistent information (i.e., their appointments, activities, and sources of financial support); and scaling up analytic capabilities to proactively identify conflicts of commitment and vulnerabilities of pre-publication research. Furthermore, NSF will focus on the delivery of training resources to the research community to ensure a clear understanding of research security issues, NSF disclosure requirements, and the tenets of beneficial international collaboration. Several of these activities are responsive to the January 2022 National Science and Technology Council implementation guidance for National Security Presidential Memorandum 33 (NSPM-33) on National Security Strategy for United States Government-Supported Research and Development[8] and to the research security provisions in the August 2022 CHIPS and Science Act.
- FY 2024 funding for NSF's Research Security activity is $13.0 million and will support the continued planning and implementation of the Research Security and Integrity Information Sharing and Analysis Organization (RSI-ISAO), as required in Sec. 10338 of the CHIPS and Science Act, and the Research on Research Security program, guided by the results of a JASON study completed in March 2023, which will support partnerships and collaborations of U.S. federal agencies and non-

[6] www.nationalacademies.org/cosempup/committee-on-science-engineering-medicine-and-public-policy
[7] www.thefdp.org/default/
[8] www.whitehouse.gov/wp-content/uploads/2022/01/010422-NSPM-33-Implementation-Guidance.pdf

profit organizations.
- The RSI-ISAO will serve as a clearinghouse for information, empowering the research community to mitigate potential foreign interference risks to safeguard the U.S.-funded research enterprise.
- The Research on Research Security program will assess the characteristics that distinguish research security from research integrity, improve the quantitative understanding of the scale and scope of research security risks, and develop methodologies to assess the potential impact of research security threats, among others.
- In FY 2023, NSF made four awards to develop research security training modules for the research community. In FY 2024, NSF will focus on delivering these modules to make them easily accessible to the research community and on evaluation of these modules.

Science and Technology Centers: Integrative Partnerships Program (STC)
- The STC program supports exceptionally innovative, complex research and education projects that require large-scale, long-term awards. STCs engage the Nation's intellectual talent in world-class research through partnerships across academia, industry, national laboratories, other public and private entities, and via international collaborations. These partnerships create synergies that enhance the training of the next generation of scientists, engineers, and educators and contributes to NSF's mission to broaden the participation of members of underrepresented groups in STEM. In FY 2024, $24.0 million supports the second year of four Class of 2023 centers. STC Administration supports post-award management of STC awards, including site visits by review teams. For more information on the STC program portfolio, see the NSF Centers Programs narrative in the NSF-Wide Investment chapter.

Science and Technology Policy Institute (STPI)
- STPI is a Federally Funded Research and Development Center sponsored by NSF on behalf of the White House Office of Science and Technology Policy (OSTP). STPI provides analysis of significant domestic and international science and technology policies and developments for OSTP and other federal agencies.

Strategic Initiatives Resources
- Through the Strategic Initiatives Resources, NSF will support activities responding to national priorities that may not align with a specific disciplinary focus or project scope. In FY 2024, this activity will emphasize the Administration's priority on climate research related activities.

People Involved in IA-Funded Activities

For detail on the People Numbers, please see the Summary Tables chapter.

ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR) $280,680,000

EPSCoR Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Percent
Total	**$215.06**	**$205.00**	**$50.00**	**$255.00**	**$280.68**	**$25.68**	**10.1%**
Research Infrastructure Improvement	162.83	148.65	50.00	198.65	221.69	23.04	11.6%
Co-Funding	52.12	55.00	-	55.00	56.14	1.14	2.1%
Outreach and Workshops	0.11	1.35	-	1.35	2.85	1.50	111.1%

[1] FY 2023 funding includes one-time funding above Congressional directed level of $245.0 million through the Strategic Initiatives Resources line for targetted investments for EPSCoR co-funding ($10.0 million).

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About EPSCoR

EPSCoR assists NSF in its statutory function "to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education." EPSCoR seeks to advance excellence in science and engineering research and education, enhancing the competitiveness of EPSCoR jurisdictions in the science and engineering domains supported by NSF.

In general, about 16 percent of the EPSCoR portfolio is available to support new research grants. The remaining 84 percent supports grants made in prior years.

EPSCoR uses three strategic investment tools: Research Infrastructure Improvement (RII) awards, Co-Funding, and Outreach/Workshops. In FY 2024, RII will expand to include new opportunities to transform and enhance research capacity and competitiveness of EPSCoR jurisdictions.

<u>Research Infrastructure Improvement (RII)</u>

- RII investments support development of physical, human, and cyber-based research infrastructure in EPSCoR jurisdictions, with an emphasis on collaborations among academic researchers, the private sector, and state and local governments, to affect sustainable improvements in research infrastructure. RII projects are designed to improve the research competitiveness of jurisdictions by strengthening their academic research infrastructure in areas of S&E supported by NSF that are critical to the jurisdiction's science and technology initiatives.
- In FY 2024, EPSCoR continues the RII Track-2: Focused EPSCoR Collaborations (RII Track-2 FEC), which builds inter-jurisdictional collaborative teams of EPSCoR investigators in scientific focus areas consistent with NSF priorities. These awards have a particular focus on the development of early career/junior faculty. In FY 2024, awards will support the Administration's R&D priority area of climate change.
- The RII Track-4: EPSCoR Research Fellows @NASA sub-track supports faculty at minority-serving institutions, women's colleges, and primarily undergraduate institutions in EPSCoR jurisdictions to collaborate with researchers at NASA research centers. In FY 2024, this activity will expand NASA research center eligibility and participation.
- In FY 2024, new programmatic opportunities will launch in response to provisions in the CHIPS and Science Act (P.L. 117-167) and three reports issued during FY 2022: (1) Envisioning the Future

of NSF EPSCoR report[9], (2) a Government Accountability Office issued report,[10] and (3) an exploratory analysis and conceptual framework for examining research competitiveness[11]. New programs will provide support to develop and coordinate core research, networks of research teams, and incubator activities to impact the jurisdiction's research ecosystem. These activities will connect individuals, institutions, and research networks and leverage other funding mechanisms, including current NSF and other federal investments. These investments will allow jurisdictions to develop both breadth and depth in discipline-specific research capacity, as well as create pathways for innovative systemic change strategies that support research and translational activities in the jurisdiction. Furthermore, these activities will nurture and expand research and economic development networks and educate and train a diverse workforce.

Co-Funding

- EPSCoR co-funding supports awards in response to meritorious proposals from individual investigators, collaborative groups, and center-scale teams based in EPSCoR-eligible jurisdictions. These proposals are submitted across all of the Foundation's research and education programs, including crosscutting initiatives, where they undergo merit review and are selected for award based on NSF's intellectual merit and broader impact criteria. EPSCoR prioritizes co-funding for awards that advance its programmatic goals, including those supporting new investigators. In FY 2024, the program will place increased emphasis on expanding support of meritorious STEM research and education proposals from EPSCoR jurisdictions across NSF, with a specific focus on early career faculty, academic research infrastructure, capacity building for center-scale and network-focused competitions, and projects that make major, potentially transformational impacts toward physical and cyberinfrastructure and the development of a diverse STEM workforce. EPSCoR co-funding ensures support for projects that might not be funded without the combined, leveraged resources of EPSCoR and the managing programs.

Outreach and Workshops

- The Outreach component of EPSCoR solicits requests for workshops, conferences, and other community-based activities. These are designed to explore opportunities in emerging areas of S&E and to share best practices in strategic planning, diversity, communication, and other capacity-building areas of importance in EPSCoR jurisdictions. EPSCoR also supports outreach travel that enables NSF staff from all directorates and offices to directly engage and inform the EPSCoR research community about NSF opportunities, priorities, programs, and policies.

Strategic Partnership and Evaluation Activities

- In FY 2024, NSF EPSCoR continues to implement a cohesive evaluation framework to study processes and outcomes that contribute to academic research competitiveness. EPSCoR will continue to identify and collect high-quality data and will work with jurisdictions to use the framework to identify opportunities for increasing their competitiveness in NSF research programs and for other federal and private S&E funding.

[9] https://beta.nsf.gov/funding/initiatives/epscor/future-nsf-epscor

[10] www.gao.gov/assets/gao-22-105043.pdf

[11] https://nsf-gov-resources.nsf.gov/2022-06/EPSCoR%20Base%20Period%20Final%20Report%20-%20%28508%20Compliant%29.pdf

UNITED STATES ARCTIC RESEARCH COMMISSION (USARC) $1,770,000

USARC Funding

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
$1.66	**$1.75**	**$1.77**	**$0.02**	**1.1%**

About USARC

USARC was created by the Arctic Research and Policy Act of 1984, (as amended, P. L. 101-609), to establish the national policy, priorities, and goals necessary to construct a federal program plan for basic and applied Arctic scientific research. USARC advises the Interagency Arctic Research Policy Committee in developing national Arctic research projects and a five-year plan to implement those projects. USARC also supports interaction with Arctic residents, international Arctic research programs and organizations, and local institutions, including regional and local governments, to obtain the broadest possible view of Arctic research needs. USARC is an independent federal agency, funded through NSF's appropriation, specifically as an activity in the Research and Related Activities account.

The FY 2024 Request for USARC is $1.77 million and will help to advance Arctic research and to recommend Arctic research policy that is consistent with the Administration's priorities.

The FY 2024 Request will fund offices in Virginia and Alaska that support eight presidentially appointed commissioners and three full-time equivalent (FTE) staff tasked with duties defined in the Arctic Research and Policy Act (ARPA) of 1984, as amended.

US Arctic Research Commission

Personnel Compensation and Benefits and General Operating Expenses

(Dollars in Thousands)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Personnel Compensation & Benefits	$965.26	$1,008.34	$1,021.98	$13.64	1.4%
Travel & Transportation of Persons	75.00	77.50	79.00	1.50	1.9%
Advisory & Assistance Services	360.00	386.50	388.00	1.50	0.4%
Rent	146.24	147.66	149.02	1.36	0.9%
Information Technology	17.50	22.00	22.50	0.50	2.3%
Communications, Supplies, Equipment, & Other Services	96.00	108.00	109.50	1.50	1.4%
Total	**$1,660.00**	**$1,750.00**	**$1,770.00**	**$20.00**	**1.1%**
Full-Time Equivalents (FTE)	3	3	3	-	-

DIRECTORATE FOR STEM EDUCATION (EDU) $1,496,180,000

EDU Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Supplemental Base	Supplemental and Science	FY 2023 Estimate Total	FY 2024 Request REVISED	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Division of Equity for Excellence in STEM (EES)	$227.03	$257.76	-	$23.00	$280.76	$326.32	$68.56	26.6%
Division of Graduate Education (DGE)	432.11	393.12	92.00	40.00	525.12	563.18	78.06	16.1%
Division of Res. on Learning in Formal & Informal Settings (DRL)	211.98	223.02	-	26.90	249.92	255.33	32.31	14.5%
Division of Undergraduate Education (DUE)	275.60	280.10	-	35.10	315.20	351.35	71.25	25.4%
Total	**$1,146.72**	**$1,154.00**	**$92.00**	**$125.00**	**$1,371.00**	**$1,496.18**	**$250.18**	**20.1%**

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

About EDU

The work of EDU closely aligns with the Administration's priorities of advancing equity, building a workforce for the needs of today and the industries of the future, and expanding opportunities in STEM everywhere. Through existing programs, EDU supports activities and research that aim to increase participation in science and engineering of individuals from racial and ethnic groups traditionally underrepresented in STEM fields, including at minority serving institutions (MSIs). STEM education and research play a central role in fostering the necessary social and economic infrastructure to support important priorities to expand clean energy, strengthen the economy, and maintain global competitiveness in emerging technologies. Now, more than ever, the Nation needs a robust STEM enterprise that includes a diverse, highly skilled U.S. STEM workforce. Both a strong STEM workforce and a STEM-literate public are needed to address societal challenges exacerbated by the global pandemic and climate change and to support a vibrant U.S. economy.

In recent years, EDU has focused on NSF priorities to reach the Missing Millions (NSF's effort to reduce the significant talent gap in STEM by increasing diversity), create and sustain new partnerships, and strengthen core STEM education activities that drive learning, broadening participation, and workforce development. EDU has expanded efforts to understand and support the needs of students whose preparation, talents, intelligence, and entrepreneurship have been historically unrecognized and underused. New partnerships with industry, private philanthropy, and other federal agencies have provided opportunities to build new research infrastructures and mutually beneficial collaborations, to expand the STEM education research community, and to increase scholarship, internship and experiential opportunities for students. EDU has a robust portfolio of programs that invest in new discoveries in STEM education, in both formal and informal learning environments. EDU's basic and use-inspired translational research informs STEM programs, policies, processes and practices, whether results are applied immediately to improve practice, or build the knowledge base to inform innovations well into the future.

In FY 2024, EDU will continue and accelerate its efforts in identifying new strategic partners to expand experiential learning opportunities, bring greater teaching and learning possibilities through novel and emerging technologies, and create innovative ecosystems to foster greater discovery and mobilize knowledge to improve STEM education at every juncture of education, especially in preK-12 schools and broad access institutions of higher learning, such as community colleges and Minority Serving Institutions (MSIs). EDU will increase both outreach and engagement with investigators, institutions of higher learning, school districts, and organizations in distressed and underserved

communities and regions around the U.S. For example, special attention will be given to the aforementioned entities located in EPSCoR jurisdictions.

EDU division allocations are designed to accomplish the collective work of the directorate, best characterized by three themes: contributing to research on STEM learning and learning environments, broadening participation and institutional capacity in STEM, and developing the STEM professional workforce. Efforts to transform STEM learning and learning environments by researching and developing successful practices in STEM education ensure that everyone can participate in the STEM enterprise. Discovery Research PreK-12 (DRK-12) and Advancing Informal STEM Learning (AISL) programs support evidence-based approaches to learning in formal and informal settings. The Improving Undergraduate Education (IUSE) program supports projects that study what works for whom and how to transform undergraduate STEM education.

The opportunities made possible by federal investments in STEM should serve and draw from the full and diverse talent pool of the Nation. As a natural extension of EDU's experience in broadening participation, EDU serves as the lead directorate and the steward of funds designated for NSF's Eddie Bernice Johnson INCLUDES initiative, which supports collaborative efforts to generate and disseminate knowledge to understand what interventions work, under what conditions, to broaden participation in STEM. EDU also continues to support the Historically Black Colleges and Universities Undergraduate Program (HBCU-UP), the Improving Undergraduate STEM Education: Hispanic-Serving Institutions (IUSE:HSI) program, and the Tribal Colleges and Universities Program (TCUP). EDU's support facilitates the advancement of early career STEM professionals at MSIs and enhances the academic experiences of students studying STEM at MSIs.

Through its scholarship, fellowship, and traineeship programs, EDU encourages the development of talent at the undergraduate and graduate levels. EDU programs such as the Advanced Technological Education (ATE) and NSF Scholarships in STEM (S-STEM) address the Nation's critical need for a skilled technical workforce that reflects the diversity of society and is attractive to employers that offer competitive salaries. The Centers of Research Excellence in Science and Technology (CREST), the NSF Research Traineeship (NRT) program, and the Graduate Research Fellowship Program (GRFP) serve to provide research experiences needed to participate fully in the workforce of the future. In FY 2024, all four EDU divisions will collaborate to sponsor more opportunities for persons with disabilities.

EDU also supports NSF and Administration priorities through NSF-wide activities. In FY 2024, EDU will continue to support the education and workforce aspects of SaTC and NITRD. EDU is also partnering with TIP in programs, such as Experiential Learning in Emerging and Novel Technologies (ExLENT), Pathways to Enable Open-Source Ecosystems (POSE), and Accelerating Research Translation (ART).

EDU continues its strong emphasis on evidence-based decision making and generating robust evidence to inform the development, management, and assessment of its portfolios of investment. A multi-year learning agenda (evidence-building plan) for EDU's STEM human capital development programs will inform and guide future actions. EDU experts in evaluation will continue to collaborate with staff in NSF's Evaluation and Assessment Capability in developing NSF-wide learning agendas and with other federal agencies to share best practices, work toward the use of common metrics and instruments, strengthen evidence-building capacity for decision-making, and support transparency and accountability.

Major Investments

EDU Major Investments
(Dollars in Millions)

Area of Investment[1,2]	FY 2022 Actual	FY 2023 Estimate Base Total[3]	FY 2024 Request REVISED	Change over FY 2023 Estimate Base Total[3] Amount	Percent
Advanced Manufacturing	$11.43	$6.00	$6.00	-	-
Artificial Intelligence	59.61	35.00	42.50	7.50	21.4%
Biotechnology	9.37	9.00	10.00	1.00	11.1%
Eddie Bernice Johnson INCLUDES Initative	23.01	27.00	50.50	23.50	87.0%
Graduate Research Fellowship Program	290.01	322.00	380.32	58.32	18.1%
Improving Undergraduate STEM Education	93.50	93.50	93.50	-	-
Microelectronics/Semiconductors	-	-	6.00	6.00	N/A
Quantum Information Science	14.08	4.00	5.00	1.00	25.0%
Secure & Trustworthy Cyberspace	63.00	74.00	74.00	-	-
STEM Education Postdoctoral Research Fellowship	-	10.00	10.50	0.50	5.0%
STEM Teacher Corps	-	-	60.00	60.00	N/A

[1] Major investments may have funding overlap and thus should not be summed.

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

To learn more about cross-agency themes and initiatives supported by EDU, such as Advanced Wireless, Artificial Intelligence, Biotechnology, Climate, Microelectronics and Semiconductors, Quantum Information Science, and Secure and Trustworthy Computing, see individual narratives in the NSF-Wide Investments chapter.

- NSF's Eddie Bernice Johnson INCLUDES Initiative: As steward of this program agency-wide, INCLUDES Initiative will continue to transform education and career pathways to help broaden participation in science and engineering and build a diverse, highly skilled American workforce. For more information, see the Big Ideas narrative within the Cross Theme Topics section of the NSF-Wide Investments chapter.

- GRFP: In FY 2024, funding for GRFP will continue to be stewarded in EDU. For more information on GRFP, see the Major Investments in STEM Graduate Education narrative within the Cross Theme Topics section of the NSF-Wide Investments chapter.

- IUSE: EDU will lead the NSF-wide IUSE activity. For more information, see the IUSE narrative within the Cross Theme Topics section of the NSF-Wide Investments chapter.

- STEM Education Postdoctoral Research Fellowship: The division formally established the program in FY 2023 to support postdoctoral awards designed to enhance the research knowledge, skills, and practices of recent doctoral graduates in STEM, STEM education, education, and related disciplines. In FY 2024 EDU will continue to award postdoctoral fellowships in STEM education to grow the community of researchers prepared to innovate across the STEM education ecosystem.

- The National STEM Teacher Corps will be launched in FY 2024 to create opportunities for the

Centers Programs

EDU Funding for Centers Programs
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base Total[1]	FY 2024 Request	Change over FY 2023 Estimate Base Total[1] Amount	Change over FY 2023 Estimate Base Total[1] Percent
Artificial Intelligence Research Institutes (DRL)	$7.68	$12.09	$12.09	-	-

[1]Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

People Numbers and Funding Profiles

For detail on the People Numbers and Funding Profile tables see the Summary Tables chapter.

Appropriations Language and Explanation of Carryover

For more information on EDU appropriations language and carryover see the Technical Information chapter.

DIVISION OF EQUITY FOR EXCELLANCE IN STEM (EES)

EES Funding

(Dollars in Millions)

			Disaster Relief Supplemental				Change over FY 2023 Base Total[2]	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
Total	**$227.03**	**$257.76**	**-**	**$23.00**	**$280.76**	**$326.32**	**$68.56**	**26.6%**
Research	152.89	175.86	-	21.00	196.86	225.49	49.63	28.2%
Education	74.14	81.90	-	2.00	83.90	100.83	18.93	23.1%

[1]Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2]Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

Aligned with the agency's goal to inspire and reach the Missing Millions in STEM, EES serves as a focal point for NSF's agency-wide commitment to broadening participation of groups historically underrepresented in STEM—minorities, women, and persons with disabilities—by enhancing the quality and excellence of STEM education and research opportunities. EES's mission is to create and grow a vibrant and diverse U.S. STEM workforce by supporting the inclusion and participation of individuals historically underrepresented in STEM and the institutions that serve them. Programs within EES have a strong focus on partnerships, alliances, and collaborations in support of institutional transformation and capacity building that lead to increased STEM participation of underrepresented groups. Priority is placed on investments in innovative and transformative strategies that serve as models for achieving the full participation of these populations and for providing opportunities for educators, researchers, and institutions, particularly at MSIs. EES will continue efforts to better engage and serve persons with disabilities, through a new program solicitation on "Workplace Equity for Persons with Disabilities in STEM and STEM Education."

FY 2024 Summary

<u>Research</u>

- AGEP funds innovative STEM faculty career pathway models for advancing doctoral students, postdoctoral scholars and faculty historically underrepresented in STEM. The AGEP program will maintain efforts to complete awardee site reviews, share best practices and collaborative partnerships findings, and network through the annual AGEP research conference.
- CREST program focuses on building research capacity at MSIs that have undergraduate enrollments of 50 percent or more of members from underrepresented groups among those holding advanced degrees in science or engineering fields. The program will continue to fund CREST centers, HBCUs through the Research Infrastructure for Science and Engineering component, and postdoctoral research fellows through the CREST Postdoc Research Program.
- The EDU Core Research (ECR) program supports fundamental STEM education research and capacity building initiatives. Research projects explore persistent and emerging, curiosity-driven, and use-inspired basic research questions with the goal of generating foundational knowledge in three broadly conceived research areas: STEM learning and learning environments, broadening participation in STEM fields, and STEM workforce development. ECR research has the potential to inform efforts at the institutional, structural, organizational, societal, and systemic levels to

enhance STEM teaching, learning, and participation in STEM education and the workforce. ECR also supports activities that build individuals' capacity to carry out high quality STEM education research. In FY 2024, ECR will continue to support fundamental research that makes important contributions to the general, explanatory knowledge that underlies STEM education, and the development of new methodologies to tackle new questions. In addition, EDU will continue efforts through the ECR Building Capacity in STEM Education Research initiative to broaden the pool of researchers who conduct, and build individuals' capacity to carry out, the high-quality STEM education research that enhances the Nation's STEM education enterprise.

- IUSE:HSI supports the improvement of undergraduate education and builds capacity for STEM education and research at HSIs that have previously received little or no funding from NSF. Outreach efforts will engage institutions new to NSF. This program is a partnership between EES with DUE (see DUE section on HSI).
- NSF's Eddie Bernice Johnson INCLUDES Initiative funds broadening participation projects and related research through Alliances and other existing NSF broadening participation portfolio programs. These include pilot projects, planning grants, and supplements that serve as on-ramps to the Alliances and the INCLUDES National Network.
- TCUP supports the design, implementation, and assessment of comprehensive institutional improvements in STEM instruction to advance the quality of student preparation in STEM at tribal colleges and universities. TCUP will continue to support projects to build and enhance STEM research capacity at TCUP institutions. TCUP will support eligible institutions through the TCUP Enterprise Advancement Centers to partner with tribal communities to enhance their ability to respond to community needs. TCUP will also continue to support in-service K-12 teacher professional development in the relevant service area, as well as upgrades to cyberinfrastructure to administer STEM programs of study and research at TCUP eligible institutions.

<u>Education</u>

- ADVANCE will continue to support evidence-based systemic change strategies to promote equity in STEM academic workplaces. ADVANCE will continue to support adaptation of successful practices for achieving institutional change.
- Excellence Awards in Science and Engineering (EASE) will continue to coordinate and support the Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) and Presidential Awards for Excellence in Science, Mathematics, and Engineering (PAESMEM) awards.
- HBCU-UP will support research for HBCU STEM faculty, enhance the academic experience of students, increase numbers of students completing STEM degrees, and support institutional transformation efforts. The program will continue to support broadening participation research through its HBCU-UP Broadening Participating Research Centers.
- Louis Stokes Alliances for Minority Participation (LSAMP) will continue to support an increased focus on broadening participation in STEM research and evaluation to expand knowledge about effective strategies for student recruitment, retention, and persistence in STEM programs. Additionally, LSAMP will emphasize support for evidence-based interventions that are proven to increase STEM baccalaureate degree production, particularly mentoring and early experiential research experiences nationally and abroad and continue support for STEM post-baccalaureate activities and will continue to support activities at the transfer and transition points.

DIVISION OF GRADUATE EDUCATION (DGE)

DGE Funding

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$432.11**	**$393.12**	**$92.00**	**$40.00**	**$525.12**	**$563.18**	**$78.06**	**16.1%**
Research	19.11	19.12	-	-	19.12	20.86	1.74	9.1%
Education	413.00	374.00	92.00	40.00	506.00	542.32	76.32	16.4%

[1] Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2] Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

DGE provides leadership for cross-Foundation efforts to support a diverse cadre of U.S. graduate students in STEM and STEM education, and to improve the nation's graduate education enterprise. DGE provides support to prepare tomorrow's STEM leaders, enhance the size, diversity, and effectiveness of the nation's STEM workforce, and contribute to a STEM-literate citizenry. The division pursues these goals through direct investment in individuals; by funding projects to develop and implement bold, new, and potentially transformative models for graduate education and training in high-priority interdisciplinary or convergent research areas; through basic research on STEM graduate education; by promoting collaborations between academic and government to produce highly trained professionals who contribute to effective governmental functioning, national defense, and US economic prosperity; and by contributing to the development of future STEM education researchers who will help to prepare students in the future. DGE's activities result in a body of research that expands the knowledge base and informs future efforts to improve STEM education by identifying successful models, practices, and approaches for the preparation of a STEM workforce ready to advance the frontiers of science and engineering.

FY 2024 Summary

<u>Research</u>

- The ECR program supports fundamental research and capacity building initiatives. ECR is managed and funded across all EDU divisions. For a full description, see the EES Division narrative.

<u>Education</u>

- The NSF GRFP will be fully funded in EDU in FY 2024 at a total funding level of $380.32 million to support at least 2,500 new fellowships, with a cost of education allowance of $16,000, increased from a previous level of $12,000, and a stipend of $37,000 per fellow. The GRFP will continue to align awards with Administration priorities. In addition, DGE will continue to pursue efforts that will ultimately ensure that GRFP applicants and recipients reflect the diversity of the US population. The GRFP will further continue to improve the graduate education experience for fellows by promoting professional development opportunities and mentoring.
- The NRT program will continue to advance transformative efforts that combine interdisciplinary training with innovative professional development activities to educate the nation's diverse future STEM professionals. NRT awardees engage masters and doctoral students in convergent research

to address problems in areas of national need, including those highlighted in the CHIPS and Science Act of 2022. As part of their graduate experience, NRT students are prepared to assume leadership roles in emerging industries, which contributes to national economic prosperity and competitiveness. The monitoring and evaluation program for NRT will continue to collect data from NRT awardees to inform future efforts. The Innovations in Graduate Education (IGE), a part of the NRT program, will continue to support research into ways to improve graduate education and training. In addition, in alignment with the CHIPS and Science Act, IGE will invest in studies and/or research to examine the impacts and outcomes of the graduate education enterprise for different groups of students. IGE will also continue to support an Innovation Acceleration Hub that will disseminate the results of IGE projects to the nation's entire STEM graduate-education community.

- SFS funding will continue to improve the capacity of institutions to provide students with the high-quality curricula and experiences to ensure that students are well prepared to enter the cybersecurity workforce. SFS support allows institutions to conduct research to identify effective preparation strategies for a variety of cybersecurity professions. SFS will also invest in the cybersecurity education and workforce development component of NSF's Secure and Trustworthy Cyberspace: Education (SaTC:EDU), by supporting projects that span educational aspects of cybersecurity and closely related fields. SaTC:EDU places focus on K-12 cybersecurity education, and on preparing students from community colleges, veterans, and members of other groups that are underrepresented in the cybersecurity field for successful entry and retention in the workforce. Beginning in FY 2023 and continuing in FY 2024, SFS will investigate the Nation's need and academic capacity to support a new SFS program focused on AI.
- The STEM Education Postdoctoral Research Fellowship was piloted as an ARP funded activity in FY 2022. DGE formally established this program in FY 2023 to support postdoctoral awards designed to enhance the research knowledge, skills, and practices of recent doctoral graduates in STEM, STEM education, education, and related disciplines, with a goal of advancing their preparation to engage in fundamental and applied research in STEM education and contribute to the academic preparation of the nation's future experts in STEM education. Each postdoctoral scholar is engaged in research that contributes to the body of knowledge related to STEM education.
- Virtual Hubs to Support Key Transitions in Professional Growth – This activity will launch in FY 2024 to address factors that cause talented and diverse individuals to disengage with STEM. The hubs' activities will focus on critical transition periods, in particular the transition from undergraduate to graduate study. This transition is particularly challenging for first-generation and low-income students as well as those who lack access to successful role models who reflect a variety of intersectional identities. DGE will partner with DUE for this activity.

For more information about GRFP, SFS, and NRT, see the Major Investments in STEM Graduate Education narrative within the Cross Theme Topics section of the NSF-Wide Investments chapter.

DIVISION OF RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS (DRL)

DRL Funding
(Dollars in Millions)

			Disaster Relief Supplemental				Change over FY 2023 Base Total[2]	
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
Total	**$211.98**	**$223.02**	**-**	**$26.90**	**$249.92**	**$255.33**	**32.31**	**14.5%**
Research	201.94	213.02	-	26.90	239.92	245.33	32.31	15.2%
Education	10.04	10.00	-	-	10.00	10.00	-	-

[1]Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2]Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

DRL invests in foundational research to advance understanding about teaching and learning in STEM, across settings ranging from preK-12 schools to the Nation's science museums. These investments address learning in all STEM fields—including computer science and emerging fields such as data science, QIS, AI, and microelectronics. With a focus on equity, the DRL portfolio addresses the design, implementation, and study of learning environments, models, and online learning platforms intended to enable STEM learning for all students—particularly those who have been underrepresented in STEM—through both formal and informal activities across the STEM ecosystem. Advances in STEM learning ultimately support individuals who pursue STEM careers, as well as the Nation’s broader workforce that will increasingly require STEM knowledge. DRL's programs inform and support lifelong access to high-quality STEM learning opportunities and promote widespread sharing of knowledge among education researchers and practitioners. In closing, DRL's efforts, in FY 2024, will focus on reaching the Missing Millions in STEM through new and existing STEM educational research and technological investments focusing on improving and enhancing teaching and learning in formal and informal settings.

FY 2024 Summary

<u>Research</u>

- AISL resources will support design, adaptation, implementation, and research on innovative modes of lifelong learning in informal environments such as science museums, community centers, and public media that have been economically challenged and serve vulnerable populations including rural and urban areas. Emphases will include equity in STEM, workforce development, adult and family learning of STEM, public participation in scientific research, remote/online learning, and climate education.
- DRK-12 focuses on research and development of resources, models, and tools to help U.S. preK-12 students learn STEM, including computer science and emerging fields such as data science, quantum information science, artificial intelligence, and microelectronics. Students benefit from a strong start in STEM education beginning in early childhood. DRK-12 supports research and development of resources for teachers and schools across diverse educational settings, including remote/online learning environments for rural and urban areas.
- The EDU Core Research (ECR) program supports fundamental research and capacity building

initiatives. ECR is managed and funded across all EDU divisions. For a full description, see the EES Division narrative.

- National Artificial Intelligence Research Institutes: EDU will support research on AI in relation to education and the workforce. The overall goal of the institutes is to improve learning and education, by incorporating AI into educational technology and anticipating how future workplaces will be changed by AI.
- Research on Innovative Technologies for Enhanced Learning will support advances in educational technology (e.g., AI, virtual and augmented reality, data analytics) and education research, with an emphasis on the most pressing needs of authentic educational environments and their teachers and learners. Such needs range from personalized students who are facing the "hurdle" of algebra to supporting teachers who are teaching about emerging technologies to making virtual and hybrid learning accessible for learners with disabilities to developing educational technologies that are cost-effective for budget-limited school districts and universities. Projects will explicitly address how educational technology is used to promote equity.

Education

- CSforAll addresses the national need to build computer science education opportunities and teacher preparation at the preK-12 level, as part of building the U.S. economy. CSforAll projects are expected to address equity issues in computer science education, including the participation of girls and women, and other underrepresented groups. In FY 2024, CSforAll will be supported at $10.0 million in EDU, with an additional $14.50 million in support from CISE.

DIVISION OF UNDERGRADUATE EDUCATION (DUE)

DUE Funding
(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request REVISED	Change over FY 2023 Base Total[2] Amount	Change over FY 2023 Base Total[2] Percent
Total	**$275.60**	**$280.10**	**-**	**$35.10**	**$315.20**	**$351.35**	**$71.25**	**25.4%**
Research	133.60	136.10	-	33.10	169.20	147.35	11.25	8.3%
Education	142.00	144.00	-	2.00	146.00	204.00	60.00	41.7%

[1]Does not capture funding provided by the American Rescue Plan supplemental appropriation.

[2]Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental base.

Closely aligned with the agency's priority to reach and inspire the Missing Millions of STEM, DUE supports excellence in undergraduate STEM education for all students, including in MSIs and broad access institutions of higher learning like community colleges. It achieves this goal by funding projects that will strengthen STEM education at two- and four-year colleges and universities. These projects include efforts to design, develop, and implement high-quality educational experiences, as well as scientific research to understand the effectiveness and impacts of those experiences. DUE investments promote educational innovations across the full range of public and private U.S. institutions of higher education, which can help to increase retention and degree attainment by undergraduates. STEM graduates have more employment opportunities and career options, as well as greater lifetime earning potential. For example, innovative educational programs at community colleges enable students to enter careers in advanced technologies such as additive manufacturing, biotechnology, precision agriculture, nano-optics, and cybersecurity. DUE support also enables STEM majors to enter the K-12 teaching workforce in high-need school districts. In these ways, DUE investments broaden participation in the future STEM workforce and help the Nation meet STEM workforce needs. In FY 2024, DUE will continue a research emphasis, initiated in FY 2022, on the learning and teaching of STEM content at 2-year institutions, which often attract diverse populations of students at various points in their careers.

FY 2024 Summary

Research

- The ECR program supports fundamental research and capacity building initiatives. ECR is managed and funded across all EDU divisions. For a full description, see the EES Division narrative.
- IUSE: HSI funds enable the improvement of undergraduate education at HSIs and build the capacity for STEM education and STEM education research at HSIs that have previously received little or no funding from NSF. Outreach efforts will continue to seek to engage institutions that are new to NSF. This program is a partnership between DUE and EES.
- IUSE is a core NSF STEM education program that seeks to promote novel, creative, and transformative approaches to generating and using new knowledge about STEM teaching and learning to improve STEM education for undergraduate students. For more information, see the IUSE narrative in the Cross Theme Topics section of the NSF-Wide Investments chapter.

Education

- ATE will support understanding and development of effective preparation that will educate the skilled technical workforce, including technicians in advanced technological industries such as advanced manufacturing.
- Noyce will continue to invest in teacher preparation and support teacher leaders during completion of a teaching obligation in high-need school districts. Noyce funds also enable the study of effective K-12 STEM pre-service teacher preparation and the retention and development of in-service teachers in high-need school districts. Outreach efforts will continue to seek to engage institutions that are new to NSF and that are MSIs. In a new initiative, to further support the community of in-service STEM teachers, Noyce will create a Regional Network of STEM Hubs (Communities of Practices) for Noyce and non-Noyce STEM teachers towards improved retention of teachers in high-need school districts. These Communities of Practice will use evidence-based practices to elevate teachers' voices, provide networking opportunities and building community, offer professional development, and engage school administrators. Participants will be compensated and have access to resources.

H-1B NONIMMIGRANT PETITIONER FEES **$198,844,080**

In FY 2024, H-1B Nonimmigrant Petitioner Fees are projected to be $198.84 million.

H-1B Nonimmigrant Petitioner Fees Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	FY 2024 Request	Change over FY 2023 Base Amount	Change over FY 2023 Base Percent
H-1B Nonimmigrant Petitioner Fees Funding	$278.48	$192.54	$198.84	$6.30	3.3%

Beginning in FY 1999, Title IV of the American Competitiveness and Workforce Improvement Act (ACWIA) of 1998 (P.L. 105-277) established an H-1B Nonimmigrant Petitioner Account in the general fund of the U.S. Treasury for fees collected for each petition for alien nonimmigrant status. The Congressional statute requires that a prescribed percentage of funds in the account be made available to NSF for scholarships to low-income STEM students; grants for mathematics, engineering, or science enrichment courses; and systemic reform activities. In FY 2005, Public Law 108-447 reauthorized H-1B funding. NSF was provided with 40 percent of the total H-1B receipts collected. Thirty percent of H-1B receipts (75 percent of the receipts that NSF receives) are to be used for a low-income scholarship program, Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM). Ten percent of receipts (25 percent of the receipts that NSF receives) are designated for support of private-public partnerships in K-12 education through Innovative Technology Experiences for Students and Teachers (ITEST).

Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM)

The S-STEM program began in 1999 under P.L. 105-277. Originally named Computer Science, Engineering, and Mathematics Scholarships (CSEMS), it supported grants for scholarships to academically talented, low-income students with financial need pursuing associate, baccalaureate, or graduate degrees in computer science, computer technology, engineering, engineering technology, or mathematics. Grantee institutions awarded scholarships of up to $2,500 per year for two years to eligible students. The CSEMS activity continued under the American Competitiveness in the 21st Century Act (P.L. 106-313) with a prescribed percentage of H-1B receipts (22 percent) which totaled approximately 59.5 percent of the total H-1B funding for NSF. P.L. 106-313 also amended P.L. 105-277 by increasing the maximum scholarship duration to four years and the annual stipend to $3,125.

Under the Consolidated Appropriations Act, 2005 (P.L. 108-447), the prescribed percentage of H-1B receipts available for the low-income scholarship program was increased to 30 percent (approximately 75 percent of the total H-1B funding for NSF). Eligibility for the scholarships was expanded from the original fields of computer science, engineering, and mathematics to include "other technology and science programs designated by the Director." The maximum annual scholarship award amount was raised from $3,125 to $10,000. Language also was added allowing NSF to use up to 50 percent of funds "for undergraduate programs for curriculum development, professional and workforce development, and to advance technological education." As a result, the program was renamed in 2006 from CSEMS to S-STEM.

Section 10393 of the CHIPS and Science Act of 2022 (Public Law. 117-167) removed language that

limited the scholarship amount to $10,000 per year and lengthened the maximum scholarship duration to five years. Thus, the maximum individual scholarship amounts were increased from $10,000 to $15,000 per year for undergraduate students and from $10,000 to $20,000 per year for graduate students for maximum duration of five years.

- Low-income Scholarship Program: S-STEM. The S-STEM program provides institutions with funds for student scholarships to encourage and enable academically talented low-income U.S. students with unmet financial need to complete an associate, baccalaureate, or graduate degree in fields of science, technology, engineering, or mathematics. Earning these degrees enables the graduates to enter the STEM workforce or STEM graduate school. The program emphasizes the importance of recruiting students to STEM disciplines, mentoring them through degree completion, and partnering with employers to facilitate student career placement in the STEM workforce.

  Since its inception, the low-income scholarship program has received more than 8,550 proposals from all types of colleges and universities and has made more than 2,350 awards. In addition to scholarships, S-STEM awards also provide funding for student support activities such as faculty mentoring, academic support, curriculum development, leadership development, and internships. These high-impact activities are known to be effective for recruiting and retaining students in high-demand technology-rich fields through graduation and into employment. In FY 2024, in addition to the long-standing scholarship support, all S-STEM projects will continue to conduct activities to inform the accumulation of knowledge about interventions that affect associate or baccalaureate STEM degree attainment by academically talented, low-income U.S. students with unmet financial need. S-STEM projects report much higher retention and graduation rates among their scholarship students than among other STEM majors. As a result, research on S-STEM projects can help the Nation understand effective practices to support STEM degree attainment at scale. To this end, the S-STEM program, through the S-STEM NET solicitation[1], fosters a network of S-STEM stakeholders and further develops the infrastructure needed to generate and disseminate new knowledge, successful practices and effective design principles arising from NSF S-STEM projects nationwide. The program is able to synthesize current achievements and investigate evolving barriers to the success of this student population and disseminate the context and circumstances by which interventions and practices that support graduation of domestic low-income students pursuing careers in STEM are successful. About 90 awards are anticipated in FY 2024, with an emphasis on increasing involvement of community colleges, especially Hispanic-serving institutions. S-STEM will continue to be a partner in the INCLUDES Initiative. S-STEM programming and research also will align with NRT, with the goal of enhancing effective learning environments and pathways for students on the continuum from two-year to four-year to master's and doctoral degrees.

Private-Public Partnerships in K-12

The American Competitiveness in the 21st Century Act (P.L. 106-313) amended P.L. 105-277 and changed the way petitioner fees were to be expended. P.L. 106-313 directed the remaining 40.5 percent of the total H-1B funding for NSF (15 percent of H-1B receipts) toward K-12 activities involving private-public partnerships in a range of areas such as materials development, student externships, and mathematics and science teacher professional development. ITEST was developed as a

[1] www.beta.nsf.gov/funding/opportunities/scholarships-stem-network-s-stem-net

partnership activity in K-12 to increase opportunities for students and teachers to learn, experience, and use information technologies within the context of STEM, including information technology (IT) courses. In FY 2005, P.L. 108-447 reduced the prescribed percentage of H-1B receipts available for private-public partnerships in K-12 to 10 percent (about 25 percent of the total H-1B funding for NSF).

- Private-Public Partnerships in K-12: ITEST. The ITEST program invests in K-12 activities that address the ongoing and growing need for STEM professionals and information technology workers in the U.S. and seeks solutions to help ensure the breadth and depth of the U.S. STEM workforce. ITEST funds activities for students and teachers that emphasize mathematics, science, and engineering and computer science careers, and emphasizes the importance of evaluation and research to understand the impact of such activities. The program supports the development, implementation, testing, and scale-up of models, STEM robotics projects, and research studies to improve the STEM workforce and build a student's capacity to participate in the STEM workforce. The solicitation places emphasis on capturing and establishing a reliable knowledge base about the dispositions toward and knowledge about STEM workforce skills in U.S. students.

  Since its inception, the ITEST program has received more than 4,630 grant proposals and made over 580 awards (including co-funded projects) that allow K-12 students and teachers to work closely with scientists, engineers, and other STEM professionals on extended research projects that promote awareness of STEM careers and interest in pursuing education pathways to those careers. The ITEST program encourages proposals relating to emerging industries such as artificial intelligence, data science, quantum information science, and microelectronics. Funded projects draw on a wide mix of community partnerships, including universities, industry, museums, science and technology centers, and school districts to identify the characteristics that attract a wide and diverse range of young people to STEM careers, especially those students historically underrepresented in those careers. ITEST will make 24-33 awards in FY 2024.

H-1B Financial Activities from FY 2013 - FY 2022

(Dollars in Millions)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
Receipts	**$120.94**	**$132.49**	**$143.00**	**$138.80**	**$141.07**	**$155.99**	**$156.72**	**$153.03**	**$213.50**	**$189.94**
Annual receipts due to NSF									*$153.50*	
DOL 2020 temporary rescission to NSF									*$60.00*	
Unobligated Balance start of year	**$99.31**	**$108.31**	**$111.39**	**$116.02**	**$74.63**	**$96.86**	**$64.68**	**$77.47**	**$124.67**	**$141.77**
Appropriation Previously unavailable (Sequestered)		**$5.10**	**$9.54**	**$7.30**	**$6.80**	**$9.73**	**$10.30**	**$9.72**	**$9.03**	**$8.75**
Appropriation Currently unavailable (Sequestered)		**-$9.54**	**-$7.30**	**-$6.80**	**-$9.73**	**-$10.30**	**-$9.72**	**-$9.03**	**-$8.75**	**-$10.83**
Rescission									**-$60.00**	
Obligations incurred:										
Scholarships in Science, Technology, Engineering, and Mathematics	83.98	92.18	109.34	140.54	84.38	156.40	114.76	79.91	94.70	243.69
Private-Public Partnership in K-12[1]	31.51	37.23	29.83	44.35	35.11	35.86	34.24	34.87	51.81	34.79
Total Obligations	**$115.49**	**$129.41**	**$139.17**	**$184.89**	**$119.49**	**$192.26**	**$149.00**	**$114.78**	**$146.51**	**$278.47**
Unallocated Recoveries	3.55	-	4.95	1.60	3.58	4.66	4.49	8.26	5.30	-0.01
Unobligated Balance end of year	**$108.31**	**$111.39**	**$122.41**	**$72.03**	**$96.86**	**$64.68**	**$77.47**	**$124.67**	**$137.24**	**$51.15**

[1] P.L. 108-447 directs that 10 percent of the H-1B Petitioner funds go toward K-12 activities involving private-public partnerships in a range of areas such as materials development, student externships, math and science teacher professional development, etc.

For information on carryover, see the Technical Information Chapter.

ORGANIZATIONAL EXCELLENCE **$802,530,000**

Organizational Excellence Funding Summary

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
$640.71	$733.40	$802.53	$69.13	9.4%

[1] Includes Administrative Cost Recoveries (ACRs) totaling $7.23 million in the FY 2022 Actual. The FY 2023 Estimate includes an ACR estimate of $7.0 million and carryover of $4.40 million.

The NSF's FY 2024 Request funding for the Organizational Excellence portfolio is $802.53 million, about seven percent of the total NSF FY 2024 Request. The Organizational Excellence portfolio underpins the agency's programmatic activities and is critical to the accomplishment of NSF's mission, "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…" As evidenced in FY 2022, NSF evaluated over 39,000 proposals through a competitive merit review process and made approximately 11,000 new competitive awards, mostly to academic institutions. In addition to these proposals, GRFP reviewed about 13,000 applications for fellowships. Almost 32,000 members of the science and engineering community participated in the merit review process as panelists and proposal reviewers.[1] Awards were made to 1,800 institutions located in all 50 states, the District of Columbia, and three U.S. territories. These activities—the merit review process, the issuance of awards, management of awards and awardees, maintaining and securing the headquarters building and NSF's IT infrastructure, and providing for NSF staff and visitors—are all supported via the Organizational Excellence portfolio.

The FY 2024 Request represents NSF's commitment to organizational excellence and reflects the agency's true operational, staffing, and administrative needs. The requested funding level will enable NSF to continue to meet agency administration and operations demands, including additional staffing needs, to effectively and efficiently meet the requirements of an $11.3 billion federal research agency. The FY 2024 Request also includes funding for an anticipated cost of living adjustment for FY 2024.

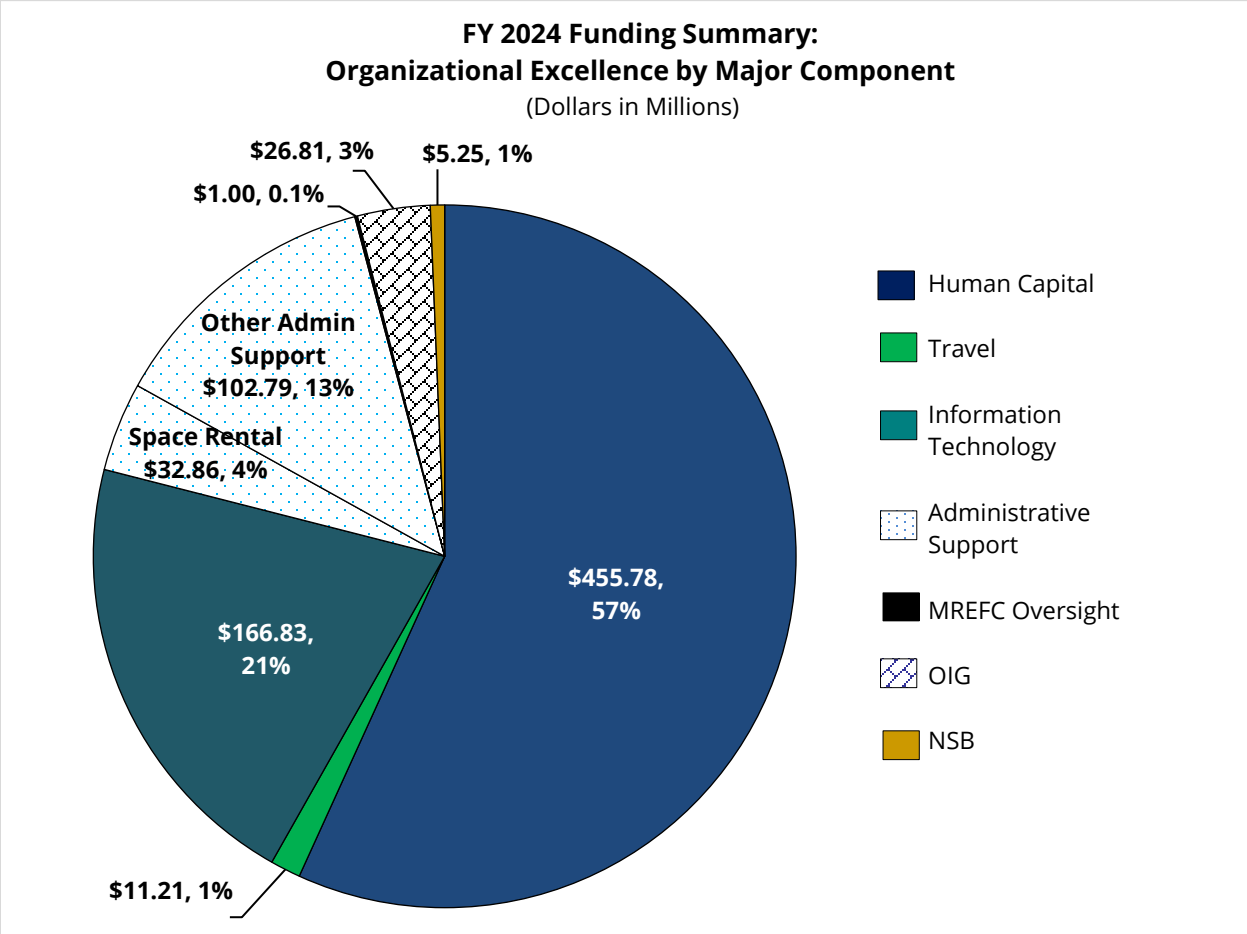
The presentation of the Organizational Excellence portfolio is organized around the major functional components instead of sorted solely by appropriation account. This presentation aligns accurately and transparently with how NSF plans and executes the budget for the Organizational Excellence portfolio activities funded by the AOAM, R&RA and EDU accounts. A summary of the FY 2024 Request justification by appropriation account is provided in this Overview, and the budget requests from OIG and NSB are presented separately within the Organizational Excellence chapter.

[1] For more information about NSF's merit review process, see www.nsf.gov/bfa/dias/policy/merit_review/ and NSF's Merit Review Process, FY 2020 Digest (NSB-2021-45) at https://nsf.gov/nsb/publications/2021/merit_review/FY-2020/nsb202145.pdf

The following section of the overview presents a summary of the FY 2024 funding for the Organization Excellence portfolio by Major Component. This is followed by an overview section presenting the same information but organized by appropriation.

Organizational Excellence by Major Component

The chart below shows the Organizational Excellence portfolio by its major components—Human Capital, Travel, Information Technology (IT), Administrative Support, MREFC Oversight, and support for OIG and NSB.



In this overview, NSF focuses its discussion on the three largest components—Human Capital, Information Technology and Administrative Support. With the exception of MREFC Oversight, every Organizational Excellence component is addressed directly in its specific chapter following the overview. A discussion of MREFC Oversight of major facility projects is discussed in the MREFC narrative of the Research Infrastructure Theme.

Human Capital

The largest component accounting for over half of Organizational Excellence, Human Capital drives the overall funding of the portfolio. It is comprised of funding for NSF's federal staff and IPAs as well as human capital management. This investment area is increased about 8 percent over FY 2023

resulting from a cost-of-living adjustment of 5.2 percent for FY 2024, and increased FTE resources for both federal FTE and IPA FTE.

NSF Workforce

The table below shows the agency's total workforce for FY 2024. A discussion of NSF's FTE allocation and usage is included in the Human Capital section of this chapter. The OIG and NSB sections of this chapter and the U.S. Arctic Research Commission section of the R&RA chapter include a discussion of their respective workforces.

NSF Workforce

Full-Time Equivalents (FTE)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
AOAM FTE	1,424	1,537	1,537	-	-
Regular	1,400	1,485	1,485	-	-
Pathways Interns[1]	24	52	52	-	-
Office of Inspector General	72	93	100	7	7.5%
Office of the National Science Board	17	18	19	1	5.6%
Arctic Research Commission	3	3	3	-	-
Total, Federal Employees (FTE)	**1,516**	**1,651**	**1,659**	**8**	**0.5%**
IPAs (FTE)	214	267	305	38	14.2%
Detailees to NSF	3	3	3	-	-
Total, NSF Workforce (FTE)	**1,733**	**1,921**	**1,967**	**46**	**2.4%**

[1] The Pathways Intern program was established by Executive Order 13562, Recruiting and Hiring Students and Recent Graduates. The internship program offers part- or full-time paid internships in federal agencies to qualifying students (students in high schools, community colleges, four-year colleges, trade schools, career and technical education programs, and other qualifying technical education programs).

Information Technology (IT)

NSF's IT is the second largest component of the Organizational Excellence portfolio, funded at $166.83 million in FY 2024. Information technology, technology innovation, and data are critical to the agency's mission. These business areas are especially critical as the agency continues to grow. Further, NSF is expanding quickly and needs to position itself with the right structure and resources so we can continue to provide outstanding information technology services to our staff and the external research community. With that in mind, the agency is proposing to create a new Office, similar to the Office of Information and Resource Management (OIRM) and the Office of Budget, Finance and Award Management (BFA)—tentatively called the Office of Business Information Technology (BIT) Services. The Office Head will also serve as the Chief Information Officer and Chief Technology Officer. All of NSF's IT activities and functions (see the IT narrative within the Organizational Excellence Chapter) that currently reside in OIRM's Division of Information Systems (DIS) will move from OIRM to BIT. Establishing this new Office will allow the NSF's IT functions to work even more effectively and efficiently.

Administrative Support

Administrative Support is the third largest component of the Organizational Excellence portfolio. The FY 2024 Request (excluding Space Rental) is $102.80 million and fully covers NSF's estimated cost of

doing business. This funding level is increased approximately 5 percent over FY 2023 for strategic investments in areas of science and security and strategic planning of evidence-building activities in support of the Agency's mission. NSF's Space Rental costs are also included in Administrative Support but tracked separately. More detailed information on Space Rental and the other activities funded in this component of the Organizational Excellence portfolio can be found within the Administrative Support narrative.

The table on the next page provides details behind the seven major components of Organizational Excellence noted in the chart above including their funding sources, as several are funded through more than one appropriation. It also frames the discussions by major component found in the rest of this chapter, with the exception of MREFC funding for oversight of major facility projects that can be found in the Research Infrastructure Theme.

Organizational Excellence by Major Component

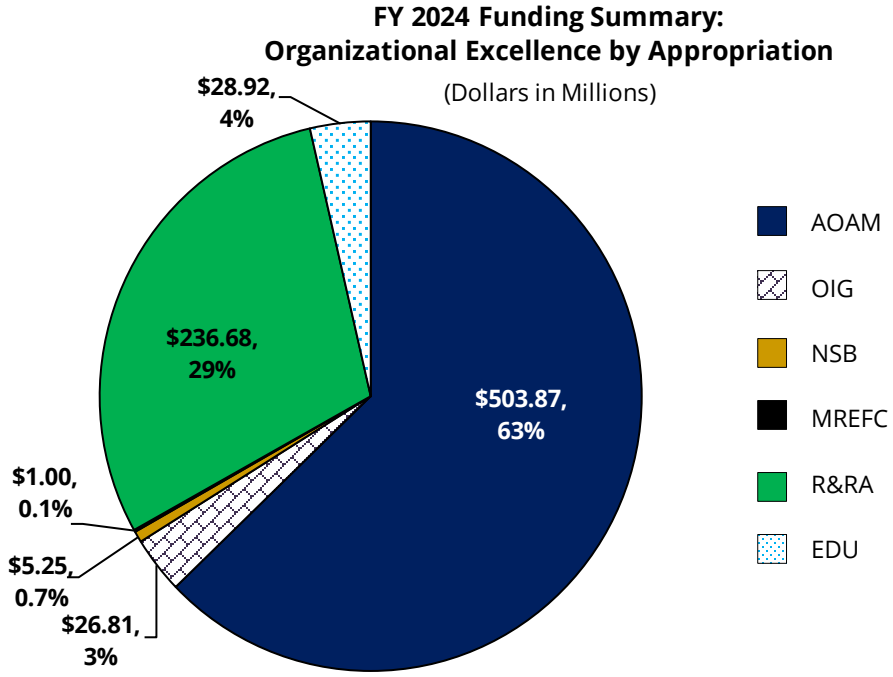
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent	Funding Source
Human Capital	$363.24	$421.54	$455.78	$34.24	8.1%	
Personnel Compensation & Benefit[1]	291.09	330.00	352.76	22.76	6.9%	AOAM
Management of Human Capital	15.39	16.79	16.790	-	-	AOAM
IPA Appointments	56.75	74.75	86.23	11.48	15.4%	
Compensation	53.87	69.33	79.85	10.52	15.2%	RRA/EDU
Per Diem	2.88	5.42	6.38	0.96	17.7%	RRA/EDU
Travel	$3.67	$10.10	$11.21	$1.11	10.9%	
NSF Federal Employee Staff	2.44	6.10	6.17	0.07	1.1%	AOAM
IPA Appointments	1.23	4.00	5.04	1.04	26.0%	RRA/EDU
Information Technology (IT)	$143.34	$147.25	$166.83	$19.58	13.3%	
Agency Operations IT	32.15	38.53	39.42	0.89	2.3%	AOAM
Administrative Applications Services and Support	8.24	11.61	9.98	-1.63	-14.0%	AOAM
Administrative IT Operations and Infrastructure	18.92	20.53	23.19	2.66	13.0%	AOAM
Administrative Security & Privacy Services	4.51	5.81	5.63	-0.18	-3.1%	AOAM
Administrative IT Management	0.48	0.58	0.62	0.04	6.9%	AOAM
Program Related Technology (PRT)	111.19	108.72	127.41	18.69	17.2%	RRA/EDU
Mission-Related Applications & Services	72.68	67.91	83.42	15.51	22.8%	RRA/EDU
Mission-Related IT Operations and Infrastructure	30.01	31.63	34.66	3.03	9.6%	RRA/EDU
Mission-Related Security & Privacy Services	6.35	6.86	6.97	0.11	1.6%	RRA/EDU
Mission-Related IT Management	2.16	2.32	2.36	0.04	1.7%	RRA/EDU
Administrative Support: Space Rental	$41.11	$27.14	$32.86	$5.71	21.1%	AOAM
Administrative Support	$65.29	$97.88	$102.79	$4.91	5.0%	
Operating Expenses	20.44	28.45	28.97	0.52	1.8%	AOAM
Building and Administrative Services	24.83	27.39	26.90	-0.49	-1.8%	AOAM
Other Program Related Administration	2.62	7.55	7.55	-	-	RRA/EDU
E-Government Initiatives	1.48	1.47	1.40	-0.07	-4.8%	RRA/EDU
General Planning and Evaluation Activities	1.14	6.08	6.15	0.07	1.2%	RRA/EDU
Other Organizational Excellence Activities	17.40	34.50	39.37	4.87	14.1%	
Major Facilities Admin Reviews and Audits	-	1.75	0.62	-1.13	-64.6%	RRA-various
Public Access Initiative	3.59	1.75	1.75	-	-	RRA-IA
Equity and Compliance in Research	-	5.00	5.00	-	-	RRA-IA
Evaluation and Assessment Capability	6.63	7.00	10.00	3.00	42.9%	RRA-IA
Modeling and Forecasting	1.51	3.00	3.00	-	-	RRA-IA
Planning and Policy Support	4.40	6.00	6.00	-	-	RRA-IA
Research Security Strategy and Policy	1.27	10.00	13.00	3.00	30.0%	RRA-CISE
MREFC Oversight	$0.65	$1.00	$1.00	-	-	MREFC
Office of Inspector General	$18.89	$23.39	$26.81	$3.42	14.6%	OIG
Office of the National Science Board	$4.52	$5.09	$5.25	$0.16	3.1%	NSB
Total	**$640.71**	**$733.40**	**$802.53**	**$69.13**	**9.4%**	

[1] Includes Administrative Cost Recoveries (ACRs) totaling $7.23 million in the FY 2022 Actual. The FY 2023 Estimate includes an ACR estimate of $7.0 million, carryover of $4.40 million, and $318.6 million of FY 2023 appropriated funds.

Organizational Excellence by Appropriation

The following presentation details NSF's Organizational Excellence portfolio by appropriation, which is funded through all of NSF's appropriation accounts.



Organizational Excellence by Appropriation

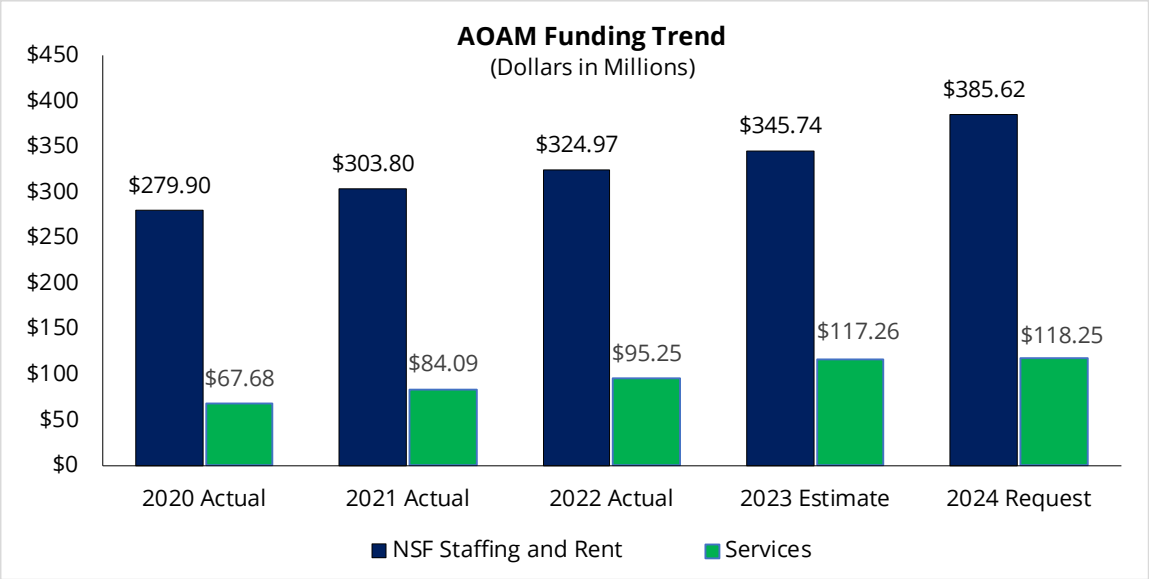
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Agency Operations & Award Management	$420.21	$463.00	$503.87	$40.87	8.8%
Office of Inspector General	18.89	23.39	26.81	3.42	14.6%
Office of the National Science Board	4.52	5.09	5.25	0.16	3.1%
Maj. Rsrch Equipment & Facilities Construction	0.65	1.00	1.00	-	-
Program Support:					
Research & Related Activities	166.38	204.28	236.68	32.40	15.9%
STEM Education	22.82	25.24	28.92	3.68	14.6%
Total NSF Appropriated Funds	**$633.47**	**$722.00**	**$802.53**	**$80.53**	**11.2%**
Administrative Cost Recoveries (ACRs)	7.23	7.00			
Carry Over		4.40			
Total Organizational Excellence	**$640.71**	**$733.40**	**$802.53**	**$69.13**	**9.4%**

Agency Operations and Award Management (AOAM)

The AOAM account provides the fundamental framework through which the Foundation's science and engineering research and education programs are administered.

At the FY 2024 Request level, AOAM funding is $503.87 million representing 63 percent of the Organizational Excellence portfolio but under five percent of the total NSF FY 2024 Request. While NSF continues to operate as a lean agency, this funding level emphasizes the importance and prioritization of current services and additional functions supporting the mission of NSF and reflects an increase for pay and benefits for NSF's federal workforce—including a 5.2 percent cost of living adjustment for FY 2024. Over three quarters (77 percent) of the requested FY 2024 AOAM funds support staffing and space rental while about one quarter (23 percent) are for mission support services.



Agency Operations and Award Management Funding Summary

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate[2]	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Personnel Compensation & Benefits (PC&B)[1]	$283.86	$318.60	$352.76	$34.16	10.7%
Management of Human Capital	15.39	16.79	16.79	-	-
Travel	2.44	6.10	6.17	0.07	1.1%
Information Technology	32.15	38.53	39.42	0.89	2.3%
Space Rental	41.11	27.14	32.86	5.71	21.1%
Operating Expenses	20.44	28.45	28.97	0.53	1.9%
Building & Administrative Services	24.83	27.39	26.90	-0.49	-1.8%
Total	**$420.21**	**$463.00**	**$503.87**	**$40.87**	**8.8%**

[1] Not included in the FY 2022 Actual is Administrative Cost Recoveries (ACRs) totaling $7.23 million for personnel costs which bring the total FY 2022 PC&B Actual to $291.09 million. Not included for FY 2023 is ACR estimates of $7.0 million and carryover of $4.40 million for personnel costs which bring the total FY 2023 Estimate for PC&B to $330.0 million.

[2] Reflects the proposed transfer of $15.0 million from R&RA to AOAM as part of the Current Plan request, still pending prior to publication. This information differs from what is shown in the President's Budget Request which shows NSF's Enacted FY 2023 funding levels.

For information on NSF's AOAM account by object class, see the AOAM by Object Class table at the end of this narrative.

Office of Inspector General

FY 2023 funding for the OIG is $26.81 million. The staffing and operations of the OIG are supported through a separate OIG appropriation. Details about the OIG FY 2024 Request can be found in the OIG narrative.

Office of the National Science Board

FY 2024 funding for the NSB is $5.25 million. The staffing and operations of the NSB office are supported through a separate NSB appropriation. Details about the NSB FY 2024 Request can be found in the NSB narrative.

Major Research Equipment and Facilities Construction

The FY 2023 Request includes $1.0 million within the MREFC account for oversight of NSF's major facility projects. For more information on this activity, see the MREFC narrative within the Research Infrastructure section of the NSF-Wide Investments chapter.

Program Support

Funding from program accounts R&RA and EDU ($265.60 million) covers approximately 33 percent of the total Organizational Excellence portfolio. Three activities comprise program-funded Organizational Excellence: Intergovernmental Personnel Act (IPA) costs, Program Related Administration including Program Related Technology, and other Organizational Excellence activities.

R&RA and EDU Organizational Excellence Funding Summary

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2023 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
IPA Costs	**$57.99**	**$78.75**	**$91.27**	**$12.52**	**15.9%**
IPA Compensation	53.87	69.33	79.85	10.52	15.2%
IPA Per Diem	2.88	5.42	6.38	0.96	17.7%
IPA Travel	1.23	4.00	5.04	1.04	26.0%
Program Related Administration	**$113.82**	**$116.27**	**$134.96**	**$18.69**	**16.1%**
Program Related Technology	111.19	108.72	127.41	18.69	17.2%
Other Program Related Administration	2.62	7.55	7.55	-	-
Other Organizational Excellence Activities	**$18.91**	**$34.50**	**$39.37**	**$4.87**	**14.1%**
Major Facilities Admin Reviews and Audits	-	1.75	0.62	-1.13	-64.6%
Public Access Initiative	3.59	1.75	1.75	-	-
Equity and Compliance in Research	1.51	5.00	5.00	-	-
Evaluation and Assessment Capability	6.63	7.00	10.00	3.00	42.9%
Modeling and Forecasting	1.51	3.00	3.00	-	-
Planning and Policy Support	4.40	6.00	6.00	-	-
Research Security Strategy and Policy	1.27	10.00	13.00	3.00	30.0%
Total	**$190.72**	**$229.52**	**$265.60**	**$36.08**	**15.7%**

AOAM by Object Class

AOAM by Object Class
(Dollars in Thousands)

	FY 2022 Actual	FY 2023 Estimate[1]	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Personnel Compensation	$211,384	$238,000	$261,690	$23,690	10.0%
Personnel Benefits	71,768	80,600	91,071	10,471	13.0%
Travel and Transportation of Persons	2,437	6,100	6,170	70	1.1%
Transportation of Things	709	769	780	11	1.4%
Rental Payments to GSA	32,959	27,140	32,860	5,720	21.1%
Rental Payments to Others	1,055	1,000	1,000	-	-
Communications, Utilities and Misc. Charges	450	450	450	-	-
Printing and Reproduction	56	55	55	-	-
Advisory and Assistance Services	53,619	54,698	55,106	408	0.7%
Other Services	33,578	36,000	36,500	500	1.4%
Purchases of Goods & Srvcs from Gov't. Accts	8,991	14,000	14,000	-	-
Operations and Maintenance of Equipment	238	238	238	-	-
Supplies and Materials	450	450	450	-	-
Equipment	2,519	3,500	3,500	-	-
Total	**$420,213**	**$463,000**	**$503,870**	**$40,870**	**8.8%**

[1] Reflects the proposed transfer of $15.0 million from R&RA to AOAM as part of the Current Plan request, still pending prior to publication. This information differs from what is shown in the President's Budget Request which shows NSF's Enacted FY 2023 funding levels.

Personnel Compensation and Benefits: Personnel compensation funds payroll, awards/bonuses, reimbursable details to NSF, overtime, and terminal leave. Personnel Benefits include the Government's contribution towards retirement systems, health and life insurance, thrift saving plans, special overseas allowances, unemployment insurance, transit subsidies, and employee relocations.

Travel and Transportation of Persons: These resources fund travel required for planning, outreach, and the increased oversight of existing awards recommended by the agency's Inspector General.

Transportation of Things: This category consists of household moves associated with bringing new staff to NSF.

Rental Payments to GSA: This category includes the rent charged by GSA for NSF's facility in Alexandria, Virginia.

Rental Payments to Others: This category includes rent paid for the parking structure to the owner of the new headquarters building in Alexandria.

Communications, Utilities, and Miscellaneous Charges: This category includes all costs for telephone and other communication lines and services, both local and long distance, and postage.

Printing and Reproduction: This category includes contract costs of composition and printing of NSF's publications, announcements, and forms, as well as printing of stationery and specialty items.

Advisory and Assistance Services: This category includes development, learning, and career enhancement opportunities offered through the NSF Academy; contracts for human capital operational activities, work life initiatives, outreach, and related services; assistance in award oversight and monitoring; and support for OMB Circular A-123 reviews.

Other Services: This category includes warehousing and supply services, mail handling, equipment repair and maintenance, building-related costs, furniture repair, contract support for conference room services, security investigations, and miscellaneous administrative contracts.

Purchases of Goods and Services from Government Accounts: This category includes reimbursable services purchased from other government agencies. Examples include Department of Homeland Security/Federal Protection Agency for security guard services; General Service Administration for some electrical upgrades and modest renovation services; and Department of the Interior for payroll services.

Operation and Maintenance of Equipment: This category includes management and operation of the central computer facility 24x7 year-round; operation of the customer service center and FastLane help desk; maintenance of database server hardware and related peripherals; software licensing fees; data communications infrastructure and network systems support; electronic mail support; and remote access (e.g., internet and World Wide Web).

Supplies and Materials: This category includes office supplies, library supplies, paper and supplies for the NSF central computer facility, and miscellaneous supplies. The FY 2021 level for this category was unusually low due to significantly less in-person activity at NSF. The FY 2023 level is consistent with increased staffing and pre-pandemic levels of spending.

Equipment: This category includes new and replacement computing equipment, desktop computers, data communications equipment, video-teleconferencing equipment, office furniture, file cabinets, and support equipment such as audio-visual equipment.

Appropriations Language and Explanation of Carryover

For more information on AOAM appropriations language and carryover see the Technical Information chapter.

HUMAN CAPITAL **$455,780,000**

Human Capital Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent	Funding Source
Personnel Compensation & Benefits[2]	$291.09	$330.00	$352.76	$22.76	6.9%	AOAM/ACRs/Carryover
Management of Human Capital	15.39	16.79	16.79	-	-	AOAM
IPA Compensation and Per Diem[1]	56.75	74.75	86.23	11.48	15.4%	R&RA/EHR
Total, Human Capital	**$363.24**	**$421.54**	**$455.78**	**$34.24**	**8.1%**	
Total AOAM	299.25	335.39	369.55	34.16	10.2%	
Total R&RA	50.93	66.57	77.14	10.57	15.9%	
Total EDU	5.82	8.18	9.09	0.91	11.1%	
ACRs	7.23	7.00				
Carryover		4.40				

[1] Costs for IPA travel are found within the Travel section of this chapter.

[2] Includes Administrative Cost Recoveries (ACRs) totaling $7.23 million in the FY 2022 Actual. The FY 2023 Estimate includes ACR estimates of $7.0 million and carryover of $4.40 million with $318.6 million of FY 2023 appropriated funds.

Support for NSF's human capital activities is the largest component of Organizational Excellence, accounting for almost 60 percent of the total portfolio. The Human Capital component includes personnel compensation and benefits (PC&B) of NSF's federal employees as well as support for NSF's temporary employees—both those that are hired through authority provided by the Intergovernmental Personnel Act, known as IPAs, and those employed through NSF's own Visiting Scientist, Engineer, and Educator (VSEE) program. NSF's federal employee full-time equivalents (FTE) and VSEEs are funded through the AOAM account while IPAs are funded through two programmatic accounts—R&RA and EDU.

The use of IPAs and VSEEs, together commonly referred to as rotators, has been a defining characteristic of NSF since its inception in 1950, as it gives NSF a direct connection to the researchers and educators working at the frontiers of science and engineering. VSEEs count as regular federal FTE and are included in the regular AOAM FTE totals. IPAs are not included in the regular AOAM FTE totals.

The Human Capital component also includes support for the Management of Human Capital, which includes:

- Human resource systems accessed through shared service providers, including the Federal Personnel Payroll System, the time and attendance system (Quicktime), and eRecruit capabilities using USAJobs.
- Operational activities including recruiting, hiring, and on-boarding of permanent and rotating staff, as well as processing support for pay and benefits and awards.
- Workplace and career-life balance support for employees including the Health Unit, Employee Assistance Program, and childcare subsidy.
- Contracts that support training and development programs, on-line training capabilities, networking activities including the NSF mentoring program, executive and supervisory training, and program management training.

Personnel Compensation and Benefits (PC&B)

Personnel Compensation & Benefits

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Regular FTE	1,400	1,485	1,485	-	-
Pathways Intern	24	52	52	-	-
Regular FTE Base Salary[1]	$208.68	$231.85	$245.55	$13.70	5.9%
Student Salary	1.14	2.96	3.17	0.21	7.0%
Other Compensation[2]	1.91	2.80	2.80	-	-
Awards	7.13	8.65	10.18	1.53	17.7%
Subtotal, FTE Compensation	**$218.86**	**$246.26**	**$261.69**	**$15.44**	**6.3%**
Benefits	71.56	82.21	89.47	7.26	8.8%
Other Benefits[3]	0.68	1.54	1.60	0.06	4.0%
Subtotal, Benefits	**$72.24**	**$83.75**	**$91.07**	**$7.33**	**8.7%**
Total, PC&B	**$291.09**	**$330.00**	**$352.76**	**$22.76**	**6.9%**

[1] Includes full support for a 4.6 percent COLA in FY 2023 ($11.01 million) and 5.2 percent in FY 2024 ($12.99 million). Includes Administrative Cost Recoveries (ACRs) totaling $7.23 million in the FY 2022 Actual. The FY 2023 Estimate includes ACR estimates of $7.0 million and carryover of $4.40 million with $318.6 million of FY 2023 appropriated funds.

[2] Includes reimbursable details to NSF and terminal leave.

[3] Includes Federal Employee's Compensation Act (FECA) funding and transit subsidies.

The FY 2024 Request for PC&B is $352.76 million and includes AOAM appropriated funds only; no Administrative Cost Recoveries (ACRs) are factored into NSF's AOAM budget plans for the FY 2024 budget submission. The FY 2024 PC&B cost estimate will support 1,485 regular FTE employees, a total of 52 Pathways intern FTE, associated cost of benefits, general workforce performance awards (GWFPA), and Senior Executive Service (SES) bonuses. It includes funding to cover a Cost of Living Adjustment in FY 2024 of 5.2 percent and also contains approximately $1.0 million for the Federal Transit Benefits Program. In total, NSF believes this PC&B estimate presents a realistic estimate of these costs in FY 2024.

NSF AOAM Workforce

NSF AOAM Workforce

(Full-Time Equivalent (FTE) and Other Staff)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Percent
NSF AOAM -- Regular	1,400	1,485	1,485	-	-
NSF AOAM -- Pathways Intern	24	52	52	-	-
Subtotal, FTE	**1,424**	**1,537**	**1,537**	**-**	-
Detailees to NSF	3	3	3	-	-
Total	**1,427**	**1,540**	**1,540**	**-**	-

Across FY 2023 and FY 2024, NSF will be expanding its regular FTE to meet the workforce needs of the larger agency. Specifically, additional FTE will be provided to NCSES to support this organization and the various activities it conducts on behalf of the federal government; as well as the TIP Directorate, the Office of Equity and Civil Rights, and Research Security Strategy and Policy, in order to achieve the program objectives set forth for these entities by the Director in the FY 2024 Request. Other FTE will be spread across NSF based on identified gaps in workforce resources and division/office needs.

Currently, planning is underway to enhance NSF's internship program in FY 2024. Within NSF, the Pathways Program is working as designed and NSF is converting interns to permanent positions at a highly successful rate. These FTE support NSF efforts to uphold Section 6 of Executive Order 14035, Advancing Diversity, Equity, Inclusion and Accessibility (DEIA) in the Federal Workforce, as these entry level positions often create a real opportunity for candidates in underserved communities to gain access to the Federal workforce.

Management of Human Capital

Management of Human Capital

(Dollars in Millions)

FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Percent
$15.39	$16.79	$16.79	-	-

The FY 2024 Request for Management of Human Capital is $16.79 million. This funding level will enable NSF to maintain operational support activities, learning and development programs essential for NSF's permanent and rotator staff, and contractual support for human capital initiatives. Many of the investments directly support NSF's Strategic Objective 4.2–Invest in People: Attract, empower, and retain a talented and diverse NSF workforce[1]. Specifically, NSF's FY 2024 Management of Human Capital investments support the following activities:

[1] Leading the World in Discovery; and Innovation; STEM Talent Development; Delivery of Benefits from Research - NSF Strategic Plan for Fiscal Years (FY) 2022 - 2026 | NSF - National Science Foundation. www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf

Learning and Development Programs ($4.58 million)
Investments in this category fund contracts in support of learning and development programs, such as the Learning Management System, LearnNSF, and related on-line learning capabilities, as well as support for learning and capacity-building activities including the NSF mentoring program, executive and supervisory training, and program management training. These learning and development activities are designed to help ensure that the workforce, including permanent and rotating staff, as well as new supervisors and executives, are equipped with the tools needed to succeed as NSF employees.

Operations Support ($4.45 million)
This category includes contract support for recruiting, hiring, and on-boarding of permanent and rotating staff, outreach, and employee surveys as well as processing support for pay, benefits, and incentive and other awards. The FY 2024 Request is guided by costs associated with these employee-driven human capital activities. These investments align with the President's Management Agenda and Executive Order 14035 ensuring that initiatives related to the NSF work environment focus on keeping NSF competitive in the labor market, able to attract, recruit, retain, and empower top talent, and advance diversity, equity, inclusion, and accessibility.

Strategic Human Capital Support ($4.67 million)
NSF relies on strategic human capital support contracts for assistance in developing new approaches to critical human resource needs. The FY 2024 Request reflects NSF's planned investment in business intelligence and other tools anticipated to bring agility and process efficiency to the agency and enable workload analysis and workforce planning in support of strategic management of human capital resources. Within this investment category, FY 2024 funds will continue support for talent teams to identify assessments which are appropriate for NSF and to improve internships and Pathways Programs. Increased funding in FY 2024 will expand competency modeling to all positions across NSF and begin work to establish career path navigation tools for employees.

Workplace and Work-Life Support ($1.79 million)
The Workplace and Work-Life Support investment is focused on helping NSF's employees by providing health and family-friendly programs and activities, including an onsite health unit, onsite fitness center, employee assistance program, childcare subsidy, backup dependent care program, and student loan repayment program. These activities address the future of employee support and help the agency remain competitive in the labor market and support Federal employees in a hybrid work environment. In FY 2024, increased funding is provided for expansion of NSF's After Hours program which provides selected participants with tuition assistance for undergraduate and graduate level classes taken during non-work hours at an accredited academic institution.

Human Resource Systems and Shared Services ($1.30 million)
This category represents NSF's HR systems accessed through shared service providers, such as the Federal Personnel Payroll System, the time and attendance system (Quicktime), and eRecruit capabilities using USAJobs. The FY 2024 Request reflects funding for USA Staffing Licenses to meet requirements related to Executive Order 13932, Modernizing and Reforming the Assessment and Hiring of Federal Job Candidates. This order requires candidate evaluations based on knowledge, skills, abilities, and competencies while limiting the use of education when determining if someone is qualified for a role. It also facilitates the use of more robust assessments over the currently used self-assessment questionnaires which are utilized for nearly all federal jobs. The increased cost for USA

Staffing is offset by elimination of Monster Hiring Solutions as Monster will no longer be needed/used as the NSF staffing/assessment platform since USA Staffing fulfills the requirements laid out in Executive Order 13932.

Intergovernmental Personnel Act Costs

A portion of NSF's workforce consists of temporary staff hired through the Intergovernmental Personnel Act (IPA) authority. IPAs remain employees of their home institution while serving at NSF during their temporary assignments. They are not paid directly by NSF and are not subject to federal pay, benefits, or other limitations. NSF reimburses their home institution without overhead. IPAs are eligible to receive relocation expenses or a per diem allowance in lieu of relocation. Since January 31, 2020, NSF has required that institutions provide a minimum of 10 percent cost share of an IPA's base salary and fringe benefits for every full-time IPA agreement.[2]

The agency uses IPA science and engineering staff to help ensure that the Foundation's funding decisions are based on the best input from the field and reflect fresh ideas and creativity. The expertise provided by these IPAs is essential to help shape the NSF research portfolio and support transformational advances across the frontiers of all fields of science, engineering, and education.

IPA Costs by Appropriation

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
IPA FTE[1]	214	267	305	38	14.2%
Research and Related Activities (R&RA)					
IPA Compensation	$48.40	$61.93	$71.63	$9.70	15.7%
IPA Per Diem	2.54	4.64	5.51	0.87	18.8%
Subtotal, R&RA Costs	**$50.93**	**$66.57**	**$77.14**	**$10.57**	**15.9%**
Education and Human Resources (EHR)					
IPA Compensation	5.47	7.40	8.22	0.82	11.1%
IPA Per Diem	0.35	0.78	0.87	0.09	11.5%
Subtotal, EDU Costs	**$5.82**	**$8.18**	**$9.09**	**$0.91**	**11.1%**
Total[1]	**$56.75**	**$74.75**	**$86.23**	**$11.48**	**15.4%**

[1] IPA FTE of approximately five in FY 2023 and FY 2024 are included in the IPA FTE lines of the table above but the costs are budgeted within Other Program Administration and included in Operating Expenses section of this chapter.

The FY 2024 IPA FTE increases 38 IPA FTE over the FY 2023 Estimate, reflecting increased needs across the agency to cover workforce demands related to the growth of the agency and the requirements of

[2] If a home institution is unable to provide the full 10 percent cost share, the institution may submit a request for NSF to waive the cost-sharing requirement. Such requests must include the rationale for not being able to provide the required amount.

the CHIPS and Science Act. The FY 2024 funding for IPA compensation and per diem costs are associated with full use of NSF's IPA FTE Request for FY 2024.

For both R&RA and EDU, per IPA compensation costs for the FY 2024 Request are estimated based on projected IPA FTE utilization, current IPA funding, and the need to provide competitive salaries to recruit the best researchers in the STEM fields. The per Diem costs are consistent with FY 2023 levels but increased over historical averages reflecting inflation and full implementation of NSF policy, beginning October 1, 2021, raising the maximum annual per Diem level to $24,984.

Information on costs associated with travel for NSF's IPAs is found within the Travel section of this chapter.

TRAVEL **$11,210,000**

NSF Travel
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent	Funding Source
NSF Federal Employee Staff[1]	$2.44	$6.10	$6.17	$0.07	1.1%	AOAM
IPA Appointments[1]	1.23	4.00	5.04	1.04	26.0%	R&RA/EHR
Total Travel	**$3.67**	**$10.10**	**$11.21**	**$1.11**	**10.9%**	
Total AOAM	2.44	6.10	6.17	0.07	1.1%	
R&RA	1.10	3.66	4.66	1.00	27.3%	
EDU	0.13	0.34	0.38	0.04	11.8%	

[1] FY 2021 funding for Federal Employee Staff and IPA travel is lower than normal due to travel restrictions related to COVID-19.

The FY 2024 Request for staff and IPA travel is $11.21 million. NSF employee travel accounts for about 55 percent of this total and is provided from the AOAM account. Travel for IPA appointments, which is supported by the R&RA and EDU accounts, is the remaining 45 percent.

As part of the review of the agency's operational and administrative needs used to develop the FY 2024 budget request, NSF analyzed historical travel data and projected estimated travel costs related to the amount of program activities anticipated at the FY 2024 Request level for NSF. In addition, travel restrictions in place for FY 2021 and into FY 2022 due to the COVID-19 pandemic were considered to be no longer in place in FY 2024 in the formulation of NSF's FY 2024 travel budget request.

NSF Employee Travel

FY 2024 funding for NSF employee full-time equivalent (FTE) travel is estimated at $6.17 million. NSF's employee FTE travel costs in FY 2024 are consistent with historical averages, in anticipation of COVID restrictions being lifted and travel resuming as normal. NSF employee FTE travel is also based on the travel activity associated with utilization of 1,485 regular FTE. It includes travel-related funding for training, site reviews, outreach activities, and post-award monitoring and oversight.

IPA Travel

The FY 2024 funding for IPA travel is $5.04 million, representing an IPA usage level of 305 IPA FTEs. The per IPA travel costs are increased in FY 2024 to levels consistent with historical averages, in anticipation of COVID restrictions being lifted and travel resuming as normal. Travel is essential to the successful completion of an IPA's duties while at NSF, which include responsibilities for oversight and stewardship of NSF's programs and awards, outreach to and engagement with scientific communities and other external stakeholders as NSF ambassadors, and maintaining their own professional prevalence (including, but not limited to, independent research and development activities).

INFORMATION TECHNOLOGY (IT) **$166,830,000**

NSF's FY 2024 Request for IT investments total $166.83 million. Funding for NSF's IT investment is provided from the AOAM, R&RA, and EDU accounts.

NSF IT Portfolio Investments by Appropriation

IT Investments by Appropriation

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent	Funding Source
AOAM IT	$32.15	$38.53	$39.42	$0.89	2.3%	AOAM
Program Related Technology (PRT)	111.19	108.72	127.41	18.69	17.2%	R&RA/EHR
Total	**$143.34**	**$147.25**	**$166.83**	**$19.58**	**13.3%**	
Total AOAM	32.15	38.53	39.42	0.89	2.3%	
Total R&RA	94.32	93.08	109.05	15.97	17.2%	
Total EDU	16.87	15.64	18.36	2.72	17.4%	

Agency IT investments funded through the AOAM account support the agency's operations to ensure high quality, reliable, and secure administrative applications and associated IT infrastructure support and services to meet the needs of the Foundation. This funding accounts for almost one quarter (24 percent) of NSF's total IT investment in the FY 2024 Request.

Program Related Technology (PRT) investments support NSF's programmatic activities and associated services and are funded through the R&RA and EDU accounts. PRT investments are mission-related IT and Data Management investments that support the merit review process, including pre-award planning and activities; receipt of proposals; processing proposals; reviewing proposals; award decisions, documentation, and notification; funding awards; post-award oversight; dissemination of award results; and award close-out. PRT investments account for just over three quarters (76 percent) of NSF's FY 2024 total funding for IT investments.

NSF's IT priorities for FY 2024 reflect the Foundation's commitment to providing excellent, equitable, and secure Federal services and customer experiences, while continuing to enhance Federal IT and cybersecurity as key enablers of mission delivery.

In FY 2024, NSF will preserve secure, reliable information technology operations and ongoing modernization of the agency's IT infrastructure and systems that support the business operations of the agency, while enabling innovation and new modernization to support NSF's strategic objectives. Advances supported by this submission include IT initiatives to: (1) Strengthen Established NSF, supporting the Foundation in expanding the frontiers of knowledge and technology; (2) Enable Participation by the "Missing Millions" to bring new, diverse perspectives into the Nation's scientific enterprise; (3) Accelerate Technology and Innovation at speed and scale; (4) Promote a Hybrid and Equitable Workforce, reducing administrative burden and ensuring equity through optimized support; and (5) Enable Data-driven Decision Making, augmenting IT services with intelligence using predictive and prescriptive technologies.

Within the FY 2024 Request, while much of the cost increase ($10.0 million or 36 percent) is driven by inflation, incremental development, new modernization, and innovation will continue based on the aforementioned priorities, including:

- Employ innovative and emerging technology capabilities to accelerate discovery and strengthen state-of-the art research, enabling NSF to increase agility of merit review and administrative functions while strengthening and empowering the agency's workforce and providing platforms for development and testing of new technology tools and capabilities;
- Continue technology transformations geared toward broadening participation, improving the customer experience, and increasing engagement both internally and for public-facing digital services, with a continued focus on modernization and digitization;
- Increase investment in technologies that enable NSF to enhance and evolve processes and to operate at speed and scale, such as utilizing technology to eliminate manual processes and improve integration between human resource management systems, and modernizing agency financial management capabilities to support budget formulation and acquisition management;
- Maintain and expand the agency's flexible and scalable IT infrastructure and systems, including technologies to support remote work, providing advanced technology capabilities to reduce administrative burden and facilitate information sharing to ensure equity while preserving secure, reliable operations; and
- Enable and enhance NSF's capabilities for data-driven decision making, building, and maturing a unified data ecosystem that leverages next generation analytics and artificial intelligence (AI).

NSF IT Portfolio Investments by Category

Investments in NSF's IT Portfolio can be grouped across five main categories: Administrative Applications Services and Support; Mission-Related Applications and Services; IT Operations and Infrastructure; IT Security and Privacy; and IT Management. Funding for the activities under these investment categories is split between AOAM and PRT.

Information Technology Portfolio by Category

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent	Funding Source
Administrative Applications Services and Support	$8.24	$11.61	$9.98	-$1.63	-14.0%	AOAM
Mission-Related Applications and Services	72.68	67.91	83.42	15.51	22.8%	PRT
IT Operations and Infrastructure	48.93	52.16	57.85	5.69	10.9%	AOAM/PRT
Security and Privacy Services	10.86	12.67	12.60	-0.07	-0.6%	AOAM/PRT
IT Management	2.63	2.90	2.98	0.08	2.8%	AOAM/PRT
Total	**$143.34**	**$147.25**	**$166.83**	**$19.58**	**13.3%**	

Administrative Applications Services and Support ($9.98 million; AOAM only)

Investments in this category support administrative applications, such as the NSF website, NSF's human resources management systems, and NSF's financial management system.

- iTRAK is NSF's financial management system. Seventy percent will be funded by PRT through the R&RA and EDU accounts and 30 percent will be funded by the AOAM account. The AOAM portion of the FY 2024 funding supports ongoing operations and maintenance of the system as well as routine technical refresh.

- Other administrative applications services which provide for operations and maintenance of agency administrative and collaboration tools, such as the NSF website. FY 2024 funding in this area will support operations and maintenance of NSF.gov.
- Continued operations and maintenance of the systems that support strategic management of NSF human capital, including those that enable the effective recruitment, retention, reskilling, and rewarding of NSF staff in alignment with NSF's Strategic Objective 4.2: Invest in People.[1] Funding in FY 2024 will support operations for the agency's core human capital management systems, including new human resource management assessment capabilities, as the agency continues expanding services to accommodate the workforce.

Mission-Related Applications and Services ($83.42 million; PRT only)

Investments in this category fund the applications and services that support the merit review process, including pre-proposal planning; receipt of proposals; processing proposals; reviewing proposals; award decisions, documentation, and notification; funding awards; post-award oversight; dissemination of award results; and award close-out. These investments can be classified as:

- Mission Support Systems, which include support for a wide range of activities:
    - Operations and maintenance of NSF's mission support systems, which provide a suite of functionality supporting each stage in the NSF proposal and award management process. Work in this area incorporates ongoing needs for new functionality as it is incrementally deployed for production use.
    - Continuous modernization of systems and services that support the merit review process. FY 2024 efforts will continue to prioritize modernization of public-facing digital services with NSF's primary focus on the services listed towards the end of this narrative in the *Prioritized Services and Forms Identified for Modernization and Digitization* section.
        - Web Modernization: Continues efforts to expand the capabilities and information shared through NSF's website, which provides the general public, science and engineering research communities, and education communities with access to high quality information and services. In FY 2024, NSF will continue agile development of NSF.gov with features and content to better serve all audiences, continue modernization of the agency's intranet site using human centered design principles and promote a suite of digital platform tools and services to support and enhance customer experience.
        - Public Access: Supports continued use of the NSF Public Access Repository (NSF-PAR) as a controlled platform for integration with third-party services, leveraging application programming interfaces that support machine-to-machine communication to enhance public access to high-quality Federal data and reduce burden on the research community. FY 2024 efforts continue system updates that enhance access to research outputs within the federated cross-agency repository.
        - Intelligent Automation of Grants Management Systems: This investment provides for incremental development and new modernization of IT systems/applications that support NSF's evolving grants management lifecycle. Investments aligned to this initiative in FY 2024 will focus on improvements to enhance non-financial aspects of the merit review process, including continued efforts to consolidate researcher profiles; enhance functions related to meeting support, reviewer management, and proposal clearance and

[1] Leading the World in Discovery; and Innovation; STEM Talent Development; Delivery of Benefits from Research - NSF Strategic Plan for Fiscal Years (FY) 2022 - 2026 | NSF - National Science Foundation https://www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf

publication; and modernize agency capabilities to electronically manage and process proposals.

- Improve Service Delivery: In FY 2024 this initiative will continue focusing on new and improved tools to enhance IT service delivery, such as strengthened infrastructure and tools that support hybrid work and improved collaboration.
- Interactive Panel Systems (IPS) Replacement: In FY 2023, NSF is expected to complete modernization of the interactive panel system, used by reviewers to collaborate with fellow panelists and review, rank, and recommend proposals; FY 2024 funding will transition to operations and maintenance support of the new IPS.
- Innovation Management: Continues the adoption and implementation of advanced tools and technologies to promote innovation, research and development, and emerging technologies to support agency priorities. Specifically, FY 2024 funding will continue efforts to expand the discovery, development, and use of citizen-developed technology and advanced capabilities such as AI, robotic process engineering (RPA), machine learning, and low-code/no-code technologies.

- NSF's Data Management and Delivery investment: NSF has prioritized agency initiatives to build a data fabric and improve access to Federal data assets and strengthen data infrastructure, further supporting the agency's use of data and evidence. FY 2024 funding includes continued investments in infrastructure, services, and systems that accelerate access to secured, real-time, well-documented enterprise data, enabling agency staff to leverage data and analytics to achieve NSF's mission. In addition, ongoing support is provided for data governance and upskilling the workforce through knowledge sharing and training in data literacy and data analytics. In FY 2024, key priorities in this area include expanded use of cutting-edge technologies and capabilities for advanced analytics, such as AI/machine learning, clustering, and text analytics.
- Support for NSF's core financial system, iTRAK: As noted above 70 percent of this request is funded by PRT with the remaining 30 percent funded by AOAM under Administrative Applications Services and Support. In FY 2024, the PRT support for iTRAK will enable NSF to begin planning for the next generation agency financial system.
- Financial services support: Enables continued agency efforts to modernize, streamline, and achieve higher efficiencies in NSF's core business and operations systems to improve transparency and accuracy of reporting between iTRAK and other mission systems that support agency awards, budget, contracting, oversight, and financial reporting functions. In FY 2024, NSF will continue account code modernization, invest in new capabilities to support budget and contract functions, and continue enhancements to core business and operations systems, focusing on account management, cost sharing, and award closeout functions.
- Human Resource System Modernization: This is an ongoing investment to modernize and enhance core agency systems for strategic management of human capital and administrative resource management. In FY 2024, NSF will prioritize capabilities for talent management, including the use of electronic assessment tools that will support agency efforts to close skill gaps.

<u>IT Operations and Infrastructure ($57.85 million; $23.19 million AOAM and $34.66 million PRT)</u>

The FY 2024 Request funding will support NSF's ongoing enhancements to agency capabilities related to network, infrastructure, data center, customer support, and database administration. Specifically, the investments in this category are classified as:

- Network: Provides access to administrative applications, services, and technologies for virtual collaboration via a single network with wired and Wi-Fi connectivity for NSF staff and visitors. FY 2024 funding supports continuous implementation of Zero Trust, modernization of NSF's

infrastructure, network, and telecommunications, including costs associated with the agency's continued adoption of Internet Protocol Version 6 (IPv6) technologies, as well as voice services via NSF's modernized voice over internet protocol (VoIP) solution and other telecommunications requirements delivered through the federal Enterprise Infrastructure Services (EIS) contract.

- Data Center and Cloud: Continues the agency use of cloud services and technologies, including the use of cloud-based email and collaboration tools, to enable further reductions in NSF's data center footprint as the agency continues to expand cloud services adoption. FY 2024 funding will support accelerated adoption and use of secure cloud infrastructure and services, including cloud migrations to modernize legacy systems and infrastructure utilizing Zero Trust Architecture principles, as well as activities to increase resilience of IT services and applications, improve speed of deployment, and support NSF's service recovery capability. Support for Data Center Facilities and Power is not included in the AOAM IT or PRT budgets discussed in this narrative but is included in the agency's IT Portfolio summary reporting and mentioned here for transparency. Funding for Data Center Facilities and Power is supported under Space Rental and referenced in the Space Rental narrative.
- End User: Provides help desk services and customer care support for internal users (NSF staff) and external users (the research community including institutions, principal investigators, reviewers, and NSF visitors), as well as support for agency-provided workstations, mobile devices, and peripherals. FY 2024 funding in this area supports continuing improvements to service delivery, including the expansion of self-help technology capabilities to improve customer experience and support NSF staff and customers who are working remotely, as well as ongoing modernization of services and devices.
- Platform: Reflects NSF's use, management, and acquisition of hyper-converged hardware, software, and services. In FY 2024, NSF will continue efforts to modernize database platforms.
- Output: Supports NSF's Print Center services. These costs are not part of the AOAM IT or PRT budget discussed in this narrative but are included in the agency's IT Portfolio summary reporting and mentioned here for transparency. Funding for Print Center services are supported under Building and Administrative Services and discussed further in that section of the Administrative Support narrative.

<u>Security and Privacy Services ($12.60 million; $5.63 million AOAM, $6.97 million PRT)</u>

Investments in this category support the portion of NSF's IT security program which provides security and compliance oversight for NSF's administrative applications and mission support systems under the direction of the NSF Chief Information Security Officer (CISO). The FY 2024 level prioritizes preservation of secure, reliable operations, including maintenance of the agency's Security Operations Center (SOC) capability providing 24/7/365 security monitoring, detection, and response capabilities; maintains support for IT operations related to NSF's Sensitive Compartmented Information Facility (SCIF) in the Alexandria facility; and prioritizes NSF's continued efforts to accelerate adoption and use of secure cloud infrastructure and services, leveraging Zero Trust Architecture. This funding level also enables NSF to continue current approaches to manage, modernize, and secure agency information, including efforts to manage supply chain risks, maintain cybersecurity vulnerability and incident response capabilities, and continue maturing capabilities to protect agency information, endpoints, and enterprise identity management solutions. In FY 2024, NSF will maintain investments in staff, tools, and professional services to support the Foundation's hybrid workforce with modern and secure capabilities and to maintain secure, reliable operations and around-the clock security monitoring. The investment includes: shared service offerings from the Department of Homeland Security (DHS) Continuous Diagnostics and Mitigation (CDM) to supplement agency monitoring

capabilities; automated configuration management tools that manage security patches and provide proactive protection from viruses, spyware, and other threats; application security; security control testing and tools; vulnerability management activities, including activities related to assessment, management, and disclosure; remediation and intrusion detection services; and activities related to cybersecurity assessment and authorization, including supply chain risk management.

Because cybersecurity is a main component of many IT investments, a significant portion of NSF's cybersecurity costs is inherently built into each component investment and thus included in that component's investment category as opposed to reported under Security and Privacy Services. In addition, as part of its mission to fund basic scientific research, NSF awards grants to the scientific community for cybersecurity research and development. Cybersecurity investments are also embedded within NSF's research support and logistics for the U.S. Antarctic Program funded through the Office of Polar Programs. These grants and the investments made through the U.S. Antarctic Program are outside of NSF's IT portfolio funded via the AOAM account and PRT. To see NSF's total Cybersecurity investments according to the National Institute of Standards and Technology categories (Identify, Protect, Detect, Respond, and Recover), please see the *NSF's Total Cybersecurity Investments* section below.

IT Management ($2.98 million; $620,000 AOAM, $2.36 million PRT)

IT Management includes support for the Chief Information Officer, Chief Data Officer, Senior Agency Official for Privacy, and senior IT leadership in the areas of IT strategy and planning, enterprise architecture, capital planning, vendor management, IT budget/finance, IT strategic communications, and support for policy and reporting efforts related to Federal IT, including compliance with the Federal Information Technology Acquisition Reform Act (FITARA). In FY 2024, investments in this category will enable NSF to continue implementation of the Technology Business Modernization (TBM) framework, further enhancing the agency's ability to manage IT as a business.

Individual Directorate/Office IT Costs Outside of NSF's Central IT Budget

With increased availability of IT tools and solutions, NSF's investment in non-central ("distributed") IT continues to grow. In an effort to increase transparency and show continuous improvement in NSF's reporting and understanding of its IT expenditures, NSF's Chief Information Officer is working to formalize reporting and governance of distributed IT investments at NSF that are funded outside of the central IT budget (AOAM IT and PRT) discussed above. Currently, NSF has identified about $5.36 million of distributed IT costs that are being actively tracked and are included in the FY 2024 IT Portfolio summary reporting.

NSF Funding for E-Government Initiatives

The tables below show NSF's contributions and service fees for various E-Government and Line of Business (LoB) initiatives. These costs are not part of the AOAM IT or PRT budget discussed in this narrative but are included in the agency's IT Portfolio summary reporting and mentioned here for transparency. Both the FY 2023 and FY 2024 levels are consistent with the funding amounts provided to NSF by the initiatives' respective managing partners.

NSF FY 2023 Request Funding for E-Government and Line of Business (LoB) Initiatives

		Appropriations Account	
Initiative	NSF Total	AOAM	R&RA
Grants.gov	$325,000	-	$325,000
Geospatial LoB	25,000	-	25,000
E-Rulemaking	23,474	23,474	-
Federal Audit Clearing House	89,424	-	89,424
Integrated Acquisition Environment (IAE)	719,644	21,000	698,644
Human Resources Management LoB	68,478	-	68,478
Financial Management LoB	139,094	-	139,094
Budget Formulation/Execution LoB	120,000	-	120,000
Total	**$1,510,114**	**$44,474**	**$1,465,640**

NSF FY 2024 Request Funding for E-Government and Line of Business (LoB) Initiatives

		Appropriations Account	
Initiative	NSF Total	AOAM	R&RA
Grants.gov	$322,000	-	$322,000
Geospatial LoB	25,000	-	25,000
E-Rulemaking	17,017	17,017	-
Federal Audit Clearing House	93,627	-	93,627
Integrated Acquisition Environment (IAE)	649,723	21,000	628,723
Human Resources Management LoB	68,478	-	68,478
Financial Management LoB	139,094	-	139,094
Budget Formulation/Execution LoB	120,000	-	120,000
Total	**$1,434,939**	**$38,017**	**$1,396,922**

Prioritized Services and Forms Identified for Modernization and Digitization

Service/Form Name	Brief description
NSF website modernization	The Foundation's main public-facing website, NSF.gov, delivers news and information to the public regarding research, funding, and awards. NSF continues to move to a modern website platform (beta.nsf.gov) to further enhance customer interactions and create a content-rich experience for users. Upcoming modernization efforts include: • Improvements to the "Funding" and "Awards" sections of the site that make it easier for users to find high-priority information. • A new and improved "About NSF" section of the site. • Updated navigation, with a universal header and footer. A new homepage for the NSF website, built using the beta site's modernized design system. • Rebranding of the beta.nsf.gov site to new.nsf.gov. This service is covered in the Web Modernization investment.
Research.gov	NSF's Research.gov system is the principal tool used by individuals and institutions to make grant proposals to NSF, receive grant awards, and comply with the terms of those grant awards. In FY 2023, NSF completed the move of Proposal Preparation and Submission capabilities from FastLane to Research.gov. Ongoing modernization efforts are focused on providing enhanced capabilities to support panelist functions, notifications and requests, research administration support, and proposal evaluation functionality. This service is covered in the Intelligent\Automation of Grants Management Systems investment.

NSF's Total Cybersecurity Investments

National Science Foundation
Total Cybersecurity Investment per the
National Institute of Standards and Technology (NIST) Categorization

(Dollars in Millions)

	FY 2022 Actual			FY 2023 Current Plan			FY 2024 Request		
NIST Category	AOAM	R&RA	EDU	AOAM	R&RA	EDU	AOAM	R&RA	EDU
Identify	$1.74	$5.36	$0.52	$1.90	$5.39	$0.53	$2.21	$5.74	$0.59
Protect[1]	6.33	189.97	65.08	8.69	191.98	76.53	8.62	195.74	76.91
Detect	1.69	3.48	0.27	2.27	3.81	0.33	2.49	3.90	0.35
Respond	0.38	1.18	0.07	0.42	1.18	0.06	0.47	1.23	0.07
Recover	0.37	1.15	0.06	0.42	1.14	0.06	0.46	1.20	0.07
Account Total	**$10.50**	**$201.14**	**$66.00**	**$13.70**	**$203.49**	**$77.51**	**$14.24**	**$207.81**	**$77.98**
NSF Total			**$277.65**			**$294.70**			**$300.04**

[1] The Protect category includes investments within the R&RA and EDU account for Cybersecurity Research and Development which represents funding provided by NSF for activities aimed at providing or enhancing security to the broader Federal, military, or national digital ecosystems.

ADMINISTRATIVE SUPPORT **$135,650,000**

FY 2024 funding for Administrative Support is $135.65 million, the third largest component of the Organizational Excellence portfolio. The activities that comprise this major component are Space Rental, Operating Expenses, Building and Administrative Services, Other Program Related Administration, and Other Organizational Excellence Activities.

Administrative Support Funding
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent	Funding Source
Space Rental	$41.11	$27.14	$32.86	$5.71	21.1%	AOAM
Operating Expenses	20.44	28.45	28.97	0.52	1.8%	AOAM
Building & Administrative Services	24.83	27.39	26.90	-0.49	-1.8%	AOAM
Other Program Related Administration	2.62	7.55	7.55	-	-	R&RA/EHR
Other Organizational Excellence Activities	17.40	34.50	39.37	4.87	14.1%	R&RA
Total Administrative Support	**$106.40**	**$125.03**	**$135.65**	**$10.62**	**8.5%**	
Total, AOAM	86.38	82.98	88.73	5.75	6.9%	
Total R&RA	20.02	40.97	45.83	4.86	11.9%	
Total EDU	-	1.08	1.09	0.01	0.9%	

Each activity within Administrative Support is addressed separately below.

Space Rental

Space Rental
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Building Rental & Taxes	$24.98	$24.77	$26.55	$1.77	7.2%
Utilities	1.04	1.35	1.19	-0.16	-11.8%
Security[2]	7.11	0.35	4.43	4.08	1176.7%
Parking Rental (including parking credits)	0.66	0.68	0.69	0.02	2.4%
Total	**$33.79**	**$27.14**	**$32.86**	**$5.71**	**21.1%**
Net adjustments for Rent forward funding[1]	*7.32*				
Revised Rent Total	**$41.11**	**$27.14**	**$32.86**	**$5.71**	**21.1%**

[1] Forward funding is an appropriation of budget authority that becomes available for obligation in the last quarter of the fiscal year for the financing of ongoing contracts during the next fiscal year. The budget authority for such contracts is included in the budget totals for the year in which it is appropriated. NSF is provided this budget authority within its annual Appropriation for the AOAM account.

[2] FY 2022 Actuals of $7.11 million includes forward funding of FY 2023 costs of $3.49 million. The FY 2022 Security costs were $3.62 million.

Space Rental includes services provided by the General Services Administration (GSA) related to rent and taxes, utilities, and security provided by the Department of Homeland Security (DHS). In addition, rent paid for the parking structure to the owner of the NSF headquarters building in Alexandria, Virginia is included. Parking credit estimates will be applied to the FY 2024 level during the current plan process when remote/hybrid work impacts are better understood.

In FY 2024, NSF will occupy over 700,000 square feet of space, primarily in one leased office building located in Alexandria, Virginia. The FY 2024 Request for Space Rental is $32.86 million. Security, utilities, and parking estimates are derived from historical billing and actual contract costs, but the FY 2024 security estimate also includes a wage adjustment and inflation for guard services and basic building security based on the Federal Protective Service's (FPS) fee structure.

IT expenditures related to NSF's on-site Information Technology Data Center are included in the total FY 2024 Space Rental budget. These costs align to the TBM cost pool for "Facilities and Power". This activity is also referenced in the Information Technology narrative for transparency.

Operating Expenses

Operating Expenses by Category
(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Non-Travel Distributed	$7.20	$8.16	$8.45	$0.29	3.5%
Science & Security	0.15	2.00	2.00	-	-
Award Monitoring & Assistance	6.66	8.48	9.10	0.62	7.3%
Acquistion & Cooperative Support	1.62	1.18	1.02	-0.16	-13.3%
Financial Management & Analysis	3.95	4.37	3.89	-0.49	-11.1%
Reporting & Other	0.86	3.26	3.44	0.19	5.7%
Business & Operations	0.00	1.00	1.07	0.07	7.0%
Total	**$20.44**	**$28.45**	**$28.97**	**$0.52**	**1.8%**

The FY 2024 Request for Operating Expenses is $28.97 million. NSF's Operating Expenses can be categorized into seven main activity areas that support the agency's operational and administrative needs and includes funding for federal FTE training, supplies, and equipment; leadership activities centered around science and security; support for a wide variety of award monitoring, acquisition, financial management, and agency reporting investments; and other activities focused on innovation and continuous organizational improvement. The total estimate for Operating Expenses reinforces NSF's commitment to organizational excellence and reflects NSF's prioritization to sustain current services levels in FY 2024.

The key activities funded by NSF's FY 2024 Request for Operating Expenses include:

<u>Non-Travel Distributed ($8.45 million)</u>
Non-Travel Distributed AOAM funds federal FTE training, equipment, communications devices, and supplies for NSF's directorates and offices. The FY 2024 Request estimate is based on historical NSF

employee needs and the utilization of 1,485 regular FTE.

Science and Security ($2.0 million)

FY 2024 investments related to Science and Security within the AOAM account will support activities initiated in FY 2022 and FY 2023. Mainly this includes post-award assessment and delivery of research security training modules; contractor support for NSF's analytic capabilities to identify potential foreign interference utilizing academic literature from multiple sources to determine the extent of interactions between NSF-funded researchers and researchers located abroad; and management of a reporting system to analyze the results of the annual financial disclosure from institutions of higher education receiving $50,000 or more from foreign sources associated with a foreign country of concern. Separate but coordinated research security-related investments, led by the Chief of Research Security, Strategy and Policy, are funded within the R&RA account and discussed below under the *Other Organizational Excellence Activities* section.

Award Monitoring and Assistance ($9.10 million)

This investment category supports activities related to award administration and stewardship of NSF's portfolio of STEM awards. The FY 2024 Request will ensure sufficient capacity to support the level of pre-award reviews and post award monitoring of the grant portfolio assumed in this budget request. It also provides the necessary resources to support major research facility and mid-scale research infrastructure program monitoring and business system reviews to ensure NSF awardees are able to fulfill financial and related requirements. Finally, this category includes funding for the various outreach and educational activities that NSF offers to assist applicants in applying for awards and meeting award requirements (these activities were previously funded under the "Reporting and Other" category). Activities supported under Award Monitoring and Assistance include:

- Oversight of major facilities including business systems reviews, portfolio risk assessment, and evaluation of cost analyses.
- NSF's annual risk assessment, post-award monitoring desk reviews, post-award adjustment reviews, and documentation of the guidance and procedures for post-award monitoring and oversight processes. These advanced monitoring activities help ensure NSF awards are administered in compliance with federal regulations and NSF terms and conditions. Additionally, the results of the oversight activities are leveraged for the Financial Statement Audit and support agency efforts to manage risk and continually improve grant operations.
- An interagency agreement with the Department of Interior's Business Center (IBC) for the negotiation and issuance of indirect cost rates. This interagency agreement for a shared service covers over half the organizations for which NSF is the cognizant agency and is critical to ensure timely and accurate indirect cost rate agreements are established and available to all Federal funding agencies in accordance with 2 CFR §200.
- NSF-wide implementation of the Program Management Improvement Accountability Act (PMIAA) including expansion to the mid-scale research infrastructure portfolio, routine assessments of Major Facility oversight staff, development of training tools, and updates to position descriptions and other documentation in collaboration with NSF's Division of Human Resources Management.
- Other activities that allow NSF to promote strong grants management practices among awardees.

Acquisition and Cooperative Support ($1.02 million)

Acquisition and Cooperative Support is a new emphasis area in the FY 2024 request for Operating Expenses that primarily includes ongoing activities previously funded under other categories. The emphasis reflects the importance of an efficient and equitable acquisitions capability to strengthen

NSF operations at speed and scale. As evidenced in NSF's Build America, Buy America Implementation Plan[1] NSF has been a government-wide leader in implementation of the Build America, Buy America Act. Further, NSF's request reflects the capacity needed to support new and innovative activities proposed through the TIP Directorate and the CHIPS and Science Act. Activities funded under Acquisition and Cooperative Support include a variety of supports to NSF acquisition staff, including:

- Assistance with contract closeouts, purchase card program oversight, contract execution, database management and a contracting information online knowledge management resource. Support for oversight of the purchase card program will be supplemented with purchase card rebates, reducing the total costs to be paid from NSF's AOAM account.
- Major facilities review and audit support services which are procured by NSF in response to the American Innovation and Competitiveness Act (AICA) 2017 audit requirements and enhanced major facilities oversight activities. Additionally, financial assistance award audit services support incurred cost audits, accounting system audits, estimating system audits, and special projects that provide NSF with information that assists in the negotiation, award, administration, repricing, and settlement of major facilities financial assistance awards.

Financial Management and Analysis ($3.89 million)

Investments in this category support NSF's financial policy and reporting activities. The FY 2024 Request maintains support of our financial reporting model, transactions, and financial monitoring. It will also support planning and documentation of any needed oversight and monitoring enhancements given growth or changes in NSF's award portfolio and an anticipated transition to a new financial system in FY 2026, procurement for which will begin in FY 2025. Financial Management activities include:

- Contract staff support in BFA's Division of Financial Management (DFM) to aid in accounting operations; financial statements and external report submission; grant financial monitoring; NSF property reporting; financial systems support and internal reporting; and audit deficiencies resolution assistance. This contract support enables NSF to meet its federal financial reporting requirements and audit requirements.
- NSF's non-IT activities related to G-Invoicing will be concluding and will be in stabilization phase.
- The Data Analytics Assurance Program (DAAP) in accordance with the *Standards for Internal Control in the Federal Government* and OMB Circular No. A-123 – *Management's Responsibility for Enterprise Risk Management and Internal Control*, which require the integration of risk management and internal control functions. The DAAP provides internal control support to improve mission delivery and the accountability and effectiveness of NSF's federal programs and operations by establishing, assessing, correcting, and reporting on internal control through innovative uses of data analytics technology. The DAAP also provides enterprise risk management support for emerging mission risks.
- Services for the printing and mailing of 1099 forms; a monthly download to update routing numbers in NSF's financial system; and annual renewal of Robotic Processing Automation (RPA) licensing for BFA Staff.

Reporting and Other ($3.44 million)

This investment category supports a wide range of reporting and other activities. The FY 2024 Request reflects a current services level of funding. Investments in this category include activities such as:

[1] Build America Buy America Implementation Plan is available at https://nsf-gov-resources.nsf.gov/2022-06/BABA_Implementation_2022_508_1.pdf

- Systems and related data analysis to continue to respond to evolving information needs to provide accurate, consistent information on financial data, funding rate, award size, and other statistics to NSF staff and the public. This information is disseminated via NSF's Enterprise Information System, the Budget Internet Information System, and other reporting mechanisms. These activities support federal efforts to manage data as a strategic asset. Also included is support for budget formulation capabilities and activities to better ensure Section 508 compliance and accessibility.
- Support for the AOAM-funded portion of the Integrated Award Environment, an e-government initiative managed by the General Services Administration; as well as design and printing services for NSF's annual reports including the Annual Financial Report, performance highlights brochure, and the Congressional Budget Request.
- Support for NSF's Office of the Chief Diversity and Inclusion Officer (CDIO) which invests in activities and a proactive approach to address the need for a workforce that reflects the country we serve. Specifically, CDIO efforts support and accomplish NSF's strategic goals to broaden participation and representation. CDIO investments will help to ensure accessibility and inclusivity within NSF by supporting (1) special emphasis programs; (2) MD-715 Barrier Analysis and workforce demographic data efforts, DEIA strategic plan and agency response to equity task force recommendations; (3) DEIA Training for NSF Employees; (4) management and interaction of employee resource groups and (5) development of DEIA analytical and assessment tools.
- Support for NSF's Office of Equity and Civil Rights (OECR) which invests in activities that directly support and accomplish NSF's strategic goal to "Excel at NSF operations and management." OECR investments include: (1) promoting NSF's compliance efforts to be a model agency for equal employment opportunity; (2) engaging in proactive equal opportunity initiatives and programs to enhance NSF program delivery; and (3) promoting accountability, education, and stakeholder engagement in support of safe and inclusive research environments.

Business and Operations ($1.07 million)

The FY 2024 Request for Business and Operations will enhance internal NSF systems and processes in order to provide an agile business operations environment that enables NSF's continued global leadership in scientific research and innovation and to integrate and scale efforts to form and sustain new partnerships in research and innovation.

Building and Administrative Services

Building and Administrative Services

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
Information Dissemination	$3.36	$3.15	$3.23	$0.08	2.5%
Workplace Management[1]	14.84	17.44	16.50	-0.93	-5.3%
Panel Support, Meeting Management, and Proposal Services	6.63	6.81	7.17	0.37	5.4%
Total	**$24.83**	**$27.39**	**$26.90**	**-$0.49**	**-1.8%**

[1] Includes funding for the operations, maintenance, and technical security requirements of NSF's Sensitive Compartmented Information Facility (SCIF).

The FY 2024 Request for building and administrative services is $26.90 million, providing the full fiscal

year requirement estimated to effectively perform these three sets of activities: Information Dissemination; Workplace Management; and Panel Support, Meeting Management, and Proposal Services.

Information Dissemination ($3.23 million)

Investments in this category fund activities that support records management; extensive web-based and electronic information distribution tools that provide information to both NSF staff and the public; graphic design and commercial printing; and regulatory reporting processing and production. Activities include:

- Records management and the establishment and execution of records management policies and procedures. NSF continues to enhance data management practices which includes reducing records storage requirements at the Federal Records Center and the National Archives and Records Administration as the transition to electronic records is complete. The requested funding level will enable operations and maintenance of controlled unclassified information (CUI) marking in IT systems pursuant to Executive Order 13556, Controlled Unclassified Information.
- Communications contract support providing information to both the public and NSF staff regarding the NSF mission and related content.
- NSF website and application development and support for NSF's external website, NSF.gov.
- Graphic design including the design and creation of layouts, graphics, animation, style sheets, and color schemes for use in NSF communications in print and on the web.
- Congressional Record and Code of Federal Regulations requests for the Foundation.

Workplace Management ($16.50 million)

Workplace Management provides funding for a wide range of core business activities and infrastructure support related to space management and facility operations, property management, as well as security and emergency management. Investments for this category include:

- Operations and maintenance for the Integrated Workplace Management System which supports space, workplace and move management, conference room scheduling, and asset inventory management.
- Activities related to property to include the oversight and planning of mailroom, shipping and receiving operations and property receipt, inventory, tracking, and reporting.
- Core business activities and infrastructure support related to security and emergency management, such as security badge issuance, management of NSF Continuity of Operations Plan activities, physical security, and access control; information and reception center; and personnel security adjudication support. FY 2024 funding will also be used to establish an Operational Security (OPSEC) program concentrated around training and awareness with a primary objective of educating NSF employees on OPSEC threats and common-sense procedures that may be used to protect NSF's critical information.
- Enhancement of the agency sustainability program through adherence to all federal guidance, including Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. NSF purchased renewable energy credits (RECs) that accounted for 29.6 percent of conventional electricity use in FY 2021, which helped reduce greenhouse gas emissions by 68.1 percent from the FY 2008 baseline. NSF will continue using RECs to achieve 100 percent carbon pollution–free electricity by FY 2030.
- Maintenance of the Small and Disadvantaged Business procurement system in compliance with government wide and agency socioeconomic goals.
- Resources necessary to continue implementation of personnel vetting transformation activities

under the Trusted Workforce 2.0 initiative including continuous vetting of the workforce.

- Space management and facility operations, including development of space plans and assignments, space reconfigurations, facility service and maintenance, and transportation. The FY 2024 Request supports reimagining NSF headquarters space (e.g., renovation and reconfiguration) to accommodate remote/hybrid staff and support increased program staff. NSF continues to gather utilization and occupancy data to assess future physical space requirements to include potential impacts on the local community. The reduction shown for Workplace Management is generally centered in this investment and is due to a one-time increase in FY 2023 for building renovations required to create permanent, consolidated space for TIP's workforce.

Panel Support, Meeting Management, and Proposal Services ($7.17 million)

This category supports NSF's merit review process by providing various services for NSF staff, panelists, members of advisory committees, committees of visitors (COVs), and guests. The FY 2024 Request provides resources for these investments supporting the full estimated cost necessary to manage current services level workload requirements and maintain services for the agency. Activities include:

- Management and support of agency printing devices including copier and printer maintenance and supplies.
- Print Center services for FY 2024. For transparency, these costs are reported by NSF as part of its Information Technology portfolio Infrastructure: Output.
- Library and research assistance for the Foundation. NSF Program Directors rely on the library electronic content to understand conflicts of interest, identify panelists, search for citations, identify who is published, research innovations, and other critical merit review ancillary support.
- Management of central conference space, including activities to oversee, operate, and maintain mission-critical audiovisual and communications equipment and resources, both physical and virtual. FY 2024 funding provides the resources necessary to schedule, coordinate, and conduct NSF's onsite and virtual meetings and panels in a post-COVID work environment.
- NSF will continue supporting Section 508 program management while sustaining the infrastructure necessary to support IT Accessibility and Section 508 initiatives agency wide and in alignment with Executive Order 14035.
- Travel management services, reflecting NSF's requirement to fully support NSF staff, panelists, members of advisory committees, COVs, and guests. Transportation of household goods and relocation assistance is also covered under this activity.

Other Program Related Administration

Other Program Related Administration

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent
E-Government Initiatives	$1.48	$1.47	$1.40	-$0.07	-4.8%
General Planning and Evaluation Activities	1.14	6.08	6.15	0.07	1.2%
Total	**$2.62**	**$7.55**	**$7.55**	**-**	**-**

In FY 2024, $7.55 million for NSF's Other Program Related Administration includes funding for two

Foundation-wide activities:

- NSF support for federal E-Government initiatives that are mission-related.
- General planning and evaluation activities that are Foundation-wide.

E-Government Initiatives ($1.40 million)

The FY 2024 funding level for NSF program-supported and mission-related E-Government (E-Gov) initiatives is consistent with the FY 2024 funding amounts provided by the initiatives' respective managing partners. It also includes the addition of a new Line of Business (LoB) called the Federal Audit Clearing House. For funding level details by LoB activity, see the *NSF Funding for E-Government Initiatives* section of the Information Technology narrative within the Organizational Excellence chapter.

General Planning and Evaluation (P&E) Activities ($6.15 million)

FY 2024 funding for general P&E activities supports investments on broad programmatic and policy matters of NSF-wide scope and benefit. This includes activities to improve programmatic efficiencies, the verification and validation of performance information; IPA FTE in BFA and the Office of the Director; technical assistance and general outreach to the research community, and certain costs associated with the American Association for the Advancement of Science fellowships program. The total FY 2024 funding level is based on the level of general P&E activities and projects that occurred across FY 2022 and FY 2023 to date and anticipated activities for FY 2024. The P&E total also includes funding for cross-agency working groups and initiatives including: the Government-wide Councils ($160,030); the Federal Government Priority Goals or CAP Goals ($141,203); the Federal Executive Boards ($125,000); a Hiring Experience (HX) Group ($66,000); and a new GSA Technology Transformation Service ($29,844).The FY 2024 P&E request is an estimated level for these activities to provide a funding envelope for planning purposes; specific requests for P&E funding for specific activities will not occur until FY 2024 and may be lower than the estimate presented.

Other Organizational Excellence Activities

Other Organizational Excellence Activities

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate	FY 2024 Request	Change over FY 2023 Estimate Amount	Change over FY 2023 Estimate Percent	Program Directorate/ Office
Major Facilities Admin Review and Audit	-	$1.75	$0.62	-$1.13	-64.6%	various
Public Access Initiative	3.59	1.75	1.75	-	-	CISE
Equity and Compliance in Research	-	5.00	5.00	-	-	IA
Evaluation and Assessment Capability (EAC)	6.63	7.00	10.00	3.00	42.9%	IA
Modeling and Forecasting	1.51	3.00	3.00	-	-	IA
Planning and Policy Support	4.40	6.00	6.00	-	-	IA
Research Security Strategy and Policy	1.27	10.00	13.00	3.00	30.0%	IA
Total	**$17.40**	**$34.50**	**$39.37**	**$4.87**	**14.1%**	

Major Facilities Administrative Reviews and Audits ($620,000)

NSF includes cost estimates of administrative reviews and audits for major facilities to be funded via the R&RA account. This estimate is based on the Annual Major Facilities Portfolio Risk Assessment

conducted by staff in BFA in close coordination with cognizant program staff. Besides risk, this assessment also considers event-driven oversight activities per NSF policy, which are based, in part, on the AICA. Funding levels for the annual assessment are estimated two fiscal years out. During the current assessment period, the status of risks from the previous cycle are revisited as are the needs for oversight and monitoring. These updates are incorporated into the plans for the entire portfolio and projected funding estimates from an earlier assessment cycle often change.

Public Access Initiative ($1.75 million)
The goal of the NSF Public Access Initiative is to make the results of NSF-funded research available to the greatest extent possible, pursuant to the memorandum on *Increasing Access to the Results of Federally Funded Scientific Research*, released by the Office of Science and Technology Policy (OSTP) on February 22, 2013, and consistent with NSF's mission and long-standing policies supporting data sharing. It enables greater transparency and more access by more people to the results of NSF-funded research, and provides secure, predictable, and integrated management of publications, data, and other research products resulting from NSF funding.

The following activities are funded out IA. Brief summaries are provided below but additional information for each can be found within the IA narrative in the R&RA chapter.

Equity and Compliance in Research ($5.0 million)
In FY 2024, NSF continues investment in this activity, which supports NSF program delivery by promoting and eliminating barriers to safe and inclusive research environments to include field sites, vessels, and large facilities.

Evaluation and Assessment Capability (EAC) ($10.0 million)
EAC engages in strategic planning of evidence-building activities in support of the Agency's mission. This includes leading the development of the Agency's learning agenda, annual evaluation plan, inventory and analysis of evidence-building activities, and other activities that support the generation and use of evidence for decision making. At the FY 2024 Request level, funding will support studies prioritized in the Agency-wide learning agenda and focused on enabling program improvements.

Modeling and Forecasting ($3.0 million)
NSF will improve its enterprise analytics capability in support of advancing research, improving equity in science, and securing global leadership. NSF will expand its enterprise data and analytic capability to support data integration across customer experience surveys, modeling, and other program monitoring to inform agency strategy, programmatic decisions and investments needed for advancing NSF priorities and strategic goals.

Planning and Policy Support ($6.0 million)
Planning and Policy Support is a foundation-wide activity in the IA budget that supports select NSF-wide policy and planning activities.

Research Security Strategy and Policy (RSSP) ($13.0 million)
This activity is complementary to the Science and Security activity funded via AOAM described within the Operating Expenses section of this narrative. It is the same activity as described within in the R&RA IA narrative, but is also discussed here as part of the Organizational Excellent Portfolio. RSSP activities include the continued planning and implementation of the Research Security and Integrity

Information Sharing and Analysis Organization (RSI-ISAO), as required in Sec. 10338 of the CHIPS and Science Act, and the Research on Research Security program, guided by the results of a JASON study, which will support partnerships and collaborations of U.S. federal agencies and non-profit organizations. The RSI-ISAO will serve as a clearinghouse for information, empowering the research community to mitigate potential foreign interference risks to safeguard the U.S.-funded research enterprise. The Research on Research Security program will assess the characteristics that distinguish research security from research integrity, improve the quantitative understanding of the scale and scope of research security risks, and develop methodologies to assess the potential impact of research security threats, among others.

OFFICE OF THE NATIONAL SCIENCE BOARD (NSB) **$5,250,000**

The Appropriations Act that funds the National Science Foundation (NSF) contains a separate appropriation for NSF's National Science Board (NSB, Board). Accordingly, this FY 2024 Budget Request identifies the resources needed to support the NSB, including amounts for personnel compensation and benefits (PC&B), contract services, training, travel, supplies, materials, and equipment.

The FY 2024 Budget Request for the Office of the National Science Board is $5.25 million, an increase of $160,000 above the FY 2023 Enacted Appropriation of $5.09 million. This FY 2024 Request level will enable the NSB to fulfill its policymaking and oversight responsibilities for NSF and continue its statutory responsibilities as outlined in the NSF Act, including activities related to the authorization of major research facilities projects.

NSB Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request	Change over FY 2023 Enacted Amount	Change over FY 2023 Enacted Percent
Total	**$4.52**	**$5.09**	**$5.25**	**$0.16**	**3.1%**
Full-Time Equivalents	18	18	19	1	5.6%

Appropriations Language

For necessary expenses (including payment of salaries, authorized travel, hire of passenger motor vehicles, the rental of conference rooms in the District of Columbia, and the employment of experts and consultants under section 3109 of title 5, United States Code) involved in carrying out section 4 of the National Science Foundation Act of 1950 (42 U.S.C. 1863) and Public Law 86–209 (42 U.S.C. 1880 et seq.), ~~$5,090,000~~$5,250,000: Provided, That not to exceed $2,500 shall be available for official reception and representation expenses. (Science Appropriations Act, 2023).

National Science Board

FY 2024 Summary Statement

(Dollars in Millions)

	Enacted/ Request	Expired	Obligations Actual/ Estimates
FY 2022 Appropriation	$4.60	-$0.08	$4.52
FY 2023 Appropriation	5.09		5.09
FY 2024 Request	5.25		5.25
$ Change from FY 2023 Appropriation			$0.16
% Change from FY 2023 Appropriation			3.1%

National Science Board in Context

The NSB, established by the NSF Act of 1950, has dual responsibilities to provide national science policy advice to the President and Congress and establish policies for NSF within the framework of applicable national policies as set forth by the President and the Congress. The Board consists of 24 presidentially appointed members plus the Director of NSF as an ex officio member. Representing the broad U.S. science and engineering (S&E) research and education community, the Board serves collectively as an advisory body on S&E issues critical to the Nation. Board members serve six-year terms on staggered appointments and are drawn from industry, academe, non-profit organizations, government, and professional scientific societies representing the breadth of S&E disciplines. They are selected to represent all areas of the Nation based on their eminence in research, education, or public service.

The Board currently convenes at least four formally scheduled public meetings per year, with additional meetings as needed, to review and approve major NSF awards; provide guidance on new programs; oversee and provide policy direction to NSF; oversee the lifecycle of large facilities, including conducting site visits; and address significant S&E-related national policy issues. The Board initiates and conducts studies and reports on a range of policy topics and engages NSF's stakeholders nation-wide. The Board reviews NSF's priorities to ensure progress and consistency along the strategic direction set for NSF and to ensure balance among new investments and core programs.

Policy Responsibilities

The Board examines issues of importance to the S&E research and education communities, in general, and to NSF, in particular. Topics are determined through requests from Congress or the President, and as the Board identifies in consultation with the community and NSF management. Recent reports have examined topics such as the skilled technical workforce, mid-scale research infrastructure, operations and maintenance costs for NSF's large facilities, and the rise of China in S&E.

In May 2020, the Board released its *Vision 2030*[1] report, which provides a framework for Board oversight and accountability for the next decade. *Vision 2030* lays out a roadmap focused on four goals: delivering benefits from research, developing STEM talent for America, expanding the geography of innovation, and fostering a global science and engineering community. These goals align with and support Administration priorities, such as advancing equity, tackling the climate crisis, advancing management and performance to deliver results, and emphasizing evidence and evaluation in priority policy and mission areas.

In its first two and a half years of *Vision 2030* implementation, the NSB conducted more than 40 engagement activities with federal and state-level leaders as well as academic, scientific, and education organizations; met with Members of Congress and congressional committee staff; and engaged with the current and previous Administrations. It also highlighted issues related to talent, diversity, equity, and inclusion, and reaching the Missing Millions (i.e., people from under-represented groups in the S&E workforce) through several external panels held during NSB meetings and by engaging with NSF on the agency's strategies, goals, and metrics for measuring progress in these areas. In addition, the Board worked closely with NSF leadership to ensure that the agency was ready

[1] www.nsf.gov/nsb/publications/2020/nsb202015.pdf

for an increased budget, expanded mission, and the new Technology, Innovation, and Partnerships (TIP) directorate, which will contribute significantly to achieving the NSB's *Vision 2030* goals of delivering benefits from research, developing STEM talent, and expanding the geography of innovation.

Structure

The Board has several standing committees to assist with its responsibilities.

The **Executive Committee** (EC) includes the Director of NSF, who chairs the Committee, and four elected members from the Board, of whom two are the NSB Chair and Vice-Chair. The Board has delegated to this Committee its authority to approve awards in the rare instances when immediate action is required between Board meetings.

The **Committee on Oversight** (CO) conducts independent oversight of NSF's operations, processes for risk management, audit plans and results, and processes for complying with laws and regulations; reviews Office of the Inspector General (OIG) activities and NSF management responses; monitors audits and makes related recommendations to the Board; and oversees the Board's compliance with the Sunshine Act.

The **Committee on Strategy** (CS) provides a forum for developing the Board's strategic discussions of NSF's budget, programs, organization structure and agency vision; makes recommendations to the Board on annual Budget Requests and quadrennial Strategic Plans; and provides strategic guidance to the Board on NSF's programs.

- The **Sub-Committee on Technology, Innovation, and Partnership (S-TIP)** consults with the NSF Director on strategies, goals, and organizational changes to ensure the success of the new TIP directorate and identify, for NSB discussion, relevant governance matters.

The **Committee on National S&E Policy** (SEP) oversees development and production of the congressionally-mandated *Science and Engineering Indicators* (*Indicators*) report in collaboration with NSF's National Center for Science and Engineering Statistics (NCSES); helps ensure that the S&E information and policy resources developed by the NSB are high-quality, policy-relevant, and accessible in order to meet stakeholder needs; and helps fulfill the NSB's charge to provide ongoing information and policy advice to Congress and the President on S&E research, education, and workforce issues.

The **Committee on Awards and Facilities** (A&F) addresses strategic issues and recommends policies to the Board related to awards and MREFC projects; makes recommendations to the Board on awards and facilities; and provides lifecycle oversight on facilities and awards.

The **Committee on External Engagement** (EE) leads the NSB's communication and engagement efforts with government, industry, the public and the research and education communities, and helps the Board advance the pursuit of national policies for the promotion of research and education in S&E. EE also reviews nominations for two awards established by the Board: the Vannevar Bush Award and the Science and Society Award.

Ongoing activities of the Board include review and approval of:

- Large awards, MREFC projects, and other proposals, as needed;
- NSF's Management Response to the OIG Semi-annual Reports to Congress;
- Transmittal of the NSF, OIG, and NSB budget submissions to the Office of Management and Budget;
- Priority order of projects in the MREFC Account;
- Midscale Research Instrumentation-2 awards (and oversight of the Midscale Research Instrumentation-1 awards); and
- Inclusion of new projects requiring funding under the MREFC Account.

The Board also reviews and makes recommendations on:
- NSF's financial management reports;
- The operation of NSF's merit review system, and;
- NSF's research infrastructure portfolio.

Financial Discussion

This FY 2024 Request will enable the NSB to fulfill its policymaking and oversight responsibilities for NSF and continue its statutory responsibilities as outlined in the NSF Act, including activities related to the authorization of major research facilities projects. The Request will enhance the Board's ability to provide strategic guidance and conduct the oversight required as NSF's budget and mission expand with a new TIP strategic focus, to engage with stakeholders, and to respond to Congressional requests.

Office of the National Science Board

Personnel Compensation and Benefits and Other Operating Expenses

(Dollars in Thousands)

	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request	Change over FY 2023 Enacted Amount	Change over FY 2023 Enacted Percent
Personnel Compensation & Benefits (PC&B)[1]	$3,234	$3,800	$4,075	$275	7.2%
Staff Development & Training	13	21	11	-10	-47.6%
Advisory & Assistance Services	1,164	991	786	-205	-20.7%
Travel & Transportation of Persons	89	250	351	101	40.4%
Communications, Supplies, & Equipment	19	25	24	-1	-4.0%
Representation Costs	-	3	3	-	-
Total	**$4,519**	**$5,090**	**$5,250**	**$160**	**3.1%**
Full-Time Equivalents (FTE)	17	18	19	1	5.6%

[1] PC&B includes base salary costs and anticipated within grade and promotion increases.

Personnel Compensation and Benefits

The Board's FY 2024 Request supports a core of full-time policy, communications, administrative, legal, and executive secretariat staff. In addition to providing institutional memory for the Board, the NSBO staff provides both the resources and expertise for coordinating and conducting science and education policy analyses and developing and implementing broad communication and outreach programs. Staff also advise the Board on legal aspects of its policies and activities and provide

operational and administrative support that are essential for the Board to fulfill its mission.

The Request reflects planned increases in NSBO staff pay, including a 5.2 percent cost-of-living adjustment, assumes in-person Board meetings and activities in FY 2024, will allow the NSBO to increase its staff by one additional FTE over the FY 2023 enacted level. This staffing level will enable the NSBO to support the NSB more effectively in exercising its governance and oversight roles by working with NSF to implement *Vision 2030,* advance the Administration's critical priorities, and meet the expectations laid out in the CHIPS and Science Act, particularly making faster and greater strides on developing talent – including the Missing Millions – and fueling the research and technologies that the US needs.

Other Operating Expenses

The Staff Development and Training budget line supports various training events such as Contracting Officer Representative (COR) training and recertification, as well as facilitation services for staff retreats that have a professional development component.

The Board's Advisory and Assistance Services budget line includes some of the resources needed to produce reports such as the Congressionally mandated *Indicators 2024*. To facilitate accessibility and use of *Indicators* data in policy decisions, analysis, and assessing progress toward *Vision 2030* goals and other critical national S&E priorities, the Board creates interactive digital products, including an electronic state data tool that allows for more frequent and timely updates and state one-pagers that highlight select data by state. The Board will also use this line to support its re-examination of NSF's Merit Review criteria through an external contract for data and information gathering and analysis. Other items in the Advisory and Assistance Services line support multimedia strategies, such as data-driven dynamic graphics, film, and video, to increase awareness and use of the Board's products by stakeholders; maintenance of an electronic official records management system, which enables compliance with federal records requirements; the webcasting and archiving of all open Board meetings; transcription services necessary for compliance with the *Government in the Sunshine Act*; and board book management software, which facilitates effective and efficient NSB meetings. This budget line also supports website maintenance costs.

The NSB's Travel and Transportation of Persons budget line primarily covers costs related to Board member travel to NSF headquarters for four annual meetings and a member-only retreat, for oversight of NSF's large programs and facilities, and for engaging stakeholders. In implementing its *Vision 2030*, the Board occasionally convenes partners and stakeholders for discussions about specific action items in the Vision Roadmap and invites speakers to participate on panels at NSB meetings. These activities help disseminate the Board's vision, galvanize momentum around key NSF and Administration priorities, elevate and understand the concerns of segments of the S&E community that are often unheard, and cultivate existing and new partners. From the beginning of the COVID-19 pandemic through mid-2022, the Board conducted such activities virtually but has returned to in-person events when circumstances allow and when cost-effective.

The Communications, Supplies, and Equipment budget line funds communications services and information technology. This budget line item includes the refreshment of IT equipment in accordance with NSF's Workstation Refresh Cycle schedule, funding of wireless equipment, and purchase of office supplies.

The FY 2024 Request will support the Board's efforts to strengthen the U.S. S&E enterprise through its policy and information-related activities. Specifically, the Request will help the NSB improve the usefulness of the resources it produces to ensure that Congress, the Administration, academia, private industry, and the public continue to have access to timely, comprehensible, and objective S&E data and policy guidance.

The Submission sets aside funds that the NSB will use, if necessary, to cover costs associated with reception and representation activities connected to official NSF business, per GAO guidance.

OFFICE OF INSPECTOR GENERAL (OIG) **$26,810,000**

The Appropriations Act that funds the National Science Foundation contains a separate appropriation for NSF's Office of Inspector General. Accordingly, this FY 2024 Budget Request identifies the resources needed to support OIG, including amounts for personnel compensation and benefits (PC&B), contract services, training, travel, supplies, materials, and equipment.

The FY 2024 Budget Request for OIG is $26.81 million, an increase of $3.42 million over the FY 2023 Enacted Appropriation of $23.39 million

OIG Funding

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request	Change over FY 2023 Enacted Amount	Change over FY 2023 Enacted Percent
Total	**$18.89**	**$23.39**	**$26.81**	**$3.42**	**14.6%**
Full-Time Equivalents (FTEs)	72	93	100	7	7.5%

OIG Responsibilities and Structure

OIG provides independent oversight of NSF's programs and operations. The office promotes effectiveness, efficiency, and economy in administering the Foundation's programs and prevents and detects fraud, waste, and abuse within NSF or by individuals who receive NSF funding. By statute, NSF OIG is organizationally independent from the agency, with the Inspector General (IG) reporting directly to the National Science Board and Congress. Given the geographic breadth of the projects NSF funds, OIG needs to be equipped to conduct audits and investigations across the continental U.S., Alaska, Hawaii, Puerto Rico, and Antarctica. To fulfill its important mission, OIG employs a diverse staff of scientists, attorneys, certified public accountants, criminal investigators, management analysts, data analysts, and information technology (IT) specialists. OIG's FY 2023 appropriation is just 0.24 percent of NSF's nearly $9.90 billion appropriation and just 0.06 percent of its $37.2 billion portfolio of active awards (as of 8/17/2022), yet OIG provides significant return on investment and serves as an invaluable safeguard against fraud, waste, abuse, and whistleblower reprisal.

OIG's work is divided into two functional areas: the Office of Audits and the Office of Investigations, which are supported by the Office of Management, the Office of Counsel, and the IG's Immediate Office. Highlights of the OIG's operational impact and strategic focus by functional area follow.

Appropriations Language

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, ~~$23,393,000~~$26,810,000, of which $400,000 shall remain available until September 30, ~~2024~~2025. (Science Appropriations Act, 2023.)

Office of Inspector General

FY 2024 Summary Statement

(Dollars in Millions)

	Enacted/ Request	Unobligated Balance Available Start of Year	Unobligated Balance Available End of Year	Adjustments to Prior Year Accounts	Obligations Actual/ Estimates
FY 2022 Appropriation	$19.00	$0.40	-$0.40	-$0.11	$18.89
FY 2023 Appropriation	23.39	0.40			23.79
FY 2024 Request	26.81				26.81
$ Change from FY 2023 Appropriation					$3.02
% Change from FY 2023 Appropriation					12.7%

Totals exclude reimbursable amounts.

Explanation of Carryover

Within the OIG two-year account, $398,292 was carried over into FY 2023.

Office of Inspector General
- Amount: $398,292
- Purpose: Funds are expected to be used to procure financial and performance audit services. The selection of awards and institutions to be audited will require careful preparation and is subject to changing circumstances and new information that may require additional time to process.
- Obligation: Anticipated FY 2023 Quarter 3

Audit Impact and Strategic Focus

OIG's Office of Audits (OA) conducts audits of NSF's contracts, cooperative agreements, and grants to universities and other research institutions, as well as internal audits of NSF's programs. These audits help ensure that financial, administrative, and programmatic activities are conducted economically, effectively, and in compliance with applicable regulations.

From FY 2017 through FY 2022, OIG audited approximately $9.6 billion in NSF funding in 37 states and Washington, D.C. These audits resulted in 131 audit engagement report and 19 other products containing a total of $17.5 million in questioned costs and 1,204 recommendations to recover misspent funds and improve awardee and NSF operations. In addition, OIG issued 537 desk reviews of federally required single audits for which NSF was the cognizant or oversight agency.

In FY 2022, OA identified more than $1.5 million in questioned costs and made 209 recommendations to strengthen program and grant operations. As a result of OIG audits, NSF recouped misspent funds and required award recipients to improve their management of NSF awards to prevent future misuse of taxpayer money. NSF also took other corrective actions in response to recent audits. For example, in FY 2022 NSF issued Standard Operating Guidance for external panel reviews of construction completion and facility readiness prior to acceptance of a major facility. NSF also developed a performance work statement for a contract for services that had previously been procured without following federal procurement guidelines. Further, in FY 2022, NSF implemented corrective actions to

limit access to sensitive information, such as social security numbers, in its Report Database to those with a current business need for the information.

Areas of Risk for Potential Audit Coverage in FY 2024

Much of OIG's audit work is mandatory, including the annual financial statement audits, the annual audits of NSFs information security program, required by the Federal Information Security Modernization Act of 2014, and the FY 2023 review of NSF's Agency Financial Report for compliance with the Payment Integrity Information Act of 2019. For discretionary audits, OA uses a risk-based approach to identify the highest priority issues that would benefit from OIG review. Although additional areas may emerge by FY 2024, the current high-risk areas include:

Directorate for Technology, Innovation and Partnerships (TIP)

In FY 2022, NSF established the TIP directorate, the agency's first new directorate in more than three decades. TIP will strive to accelerate the pace of innovation and translation in emerging technologies, address the pivotal societal and economic challenges addressing the nation, and engage diverse talents nationwide. Working collaboratively with the rest of the Foundation, other federal agencies, state, local, and tribal governments, academics, the private sector, nonprofits, civil society, and investors, TIP will seek to ensure the nation remains in the vanguard of competitiveness for decades to come. The CHIPS and Science Act of 2022 officially authorized the directorate and a number of its investments. TIP represents a transformational change to NSF's traditional mission by expanding its emphasis on applied and use-inspired research. OA will monitor how the directorate evolves and evaluate any emerging risks associated with its new programs and initiatives.

Antarctic Infrastructure Modernization Projects

The NSF Office of Polar Programs manages the U.S. Antarctic Program (USAP), through which it operates three year-round research stations and two research vessels and coordinates all U.S. science and logistical support on the southernmost continent. The Antarctic Infrastructure Modernization for Science (AIMS) project is a key component of the future USAP. AIMS includes a series of redevelopments and upgrades to the buildings, utilities, logistics, and technology that make up the USAP stations. This work, budgeted at $90.0 million in 2022, was intended to serve the continent's ongoing scientific mission over a 35 to 50-year planning horizon and was aimed at reducing costs, finding efficiencies, conserving energy, and supporting Antarctic science. Since March 2020, the McMurdo worksite has been in a safe and stable condition and all on-ice construction had been paused due to COVID-related international travel restrictions. NSF has now resumed on-ice construction. Due to the difficulties of working in Antarctica and of recovering from the pandemic, the original AIMS construction project is being re-baselined to include only the Vehicle Equipment and Operations Center (VEOC) and Lodging Building modules, with associated cost increases and possible work extending beyond the end of the current USAP contract. NSF has also identified needed investments in USAP facilities and infrastructure that cannot be deferred until after completion of the remaining AIMS' modules and is transitioning into a broader recapitalization of Antarctic infrastructure under the Antarctic Infrastructure Recapitalization (AIR) program, which includes projects at all three year-round stations. OA will continue to evaluate NSF's oversight of these critical, highly visible, long-term projects and assess the adequacy of the re-baselining process.

Harassment

NSF added an award term and condition, effective October 22, 2018, requiring award recipients to notify the agency of any findings/determinations of sexual harassment, other forms of harassment,

or sexual assault regarding an NSF funded principal investigator (PI) or co-PI. Recipients are also required to notify NSF if the PI or co-PI is placed on administrative leave or if the awardee has imposed any administrative action on the PI or any co-PI relating to any finding/determination or an investigation of an alleged violation of awardee policies or codes of conduct, statutes, regulations, or executive orders relating to sexual harassment, other forms of harassment, or sexual assault. From FY 2019 through FY 2021, NSF received 43 notifications. NSF's Office of Equity and Civil Rights receives the notifications and works with NSF staff to determine the appropriate course of action. NSF's current Proposal and Award Policies and Procedures Guide states that NSF expects all research organizations to establish and maintain clear and unambiguous standards of behavior to ensure harassment-free workplaces wherever science is conducted. Providing effective oversight of awardee compliance may be particularly difficult for NSF in certain locations, such as research vessels, small and remote labs, and Antarctica. NSF recently received a report raising concerns about harassment occurring at NSF-funded research stations and field sites in Antarctica. We will continue to monitor NSF's oversight of awardee compliance with its harassment policies, and its implementation of applicable federal requirements, including those in Combating Sexual Harassment in Science, in the CHIPS and Science Act of 2022. We will also monitor the actions NSF takes in response to the Antarctic report.

Compliance with OMB Memorandum 22-09, Moving the U.S. Government Toward Zero Trust Cybersecurity Principles

In January 2022, the Office of Management and Budget (OMB) issued memorandum M-22-09 to help move the federal government toward Zero Trust cybersecurity principles. The memorandum provides a federal zero trust architecture (ZTA) strategy, requiring agencies to meet specific cybersecurity standards and objectives by the end of FY 2024. The memorandum's goals are organized using the zero-trust maturity model developed by the Cybersecurity & Infrastructure Security Agency (CISA). CISA's zero trust model describes five complementary areas of effort (pillars): Identity, Devices, Networks, Applications and Workloads, and Data; with three themes that cut across these areas: Visibility and Analytics, Automation and Orchestration, and Governance. As part of the ZTA requirements, agencies were to submit an implementation plan by March 26, 2022, to OMB and CISA for FY 2022 through FY 2024, and a budget estimate for FY 2024. OA will monitor NSF plans for implementing the ZTA strategy, its FY 2024 budget request, and its progress in meeting the goals and objectives of M-22-09.

Award Recipient Compliance with Research Security Requirements

National Security Presidential Memorandum 33 (NSPM-33) strengthens protections of United States Government-supported research and development against foreign government interference and exploitation while maintaining an open environment to foster research discoveries and innovation that benefit the nation and the world. NSF recently updated its Proposal and Award Policies and Procedures Guide (PAPPG) to, in part, follow the research security requirements established by NSPM-33. In addition to existing conflict of interest guidance, NSF has instituted new pre-award and post-award disclosure requirements. NSPM-33 also requires research organizations awarded more than $50 million per year in total federal research funding to implement a research security program.[1] Further, the CHIPS and Science Act of 2022 enacted additional research security requirements that are applicable to both NSF and its award recipients. These various requirements establish mechanisms for managing risks related to researchers' potential conflicts, including participation in foreign government talent programs. OA will monitor NSF's implementation of NSPM-33, its

[1] Implementation guidance on this requirement has not yet been issued.

implementation of additional security requirements in the CHIPS and Science Act, and its oversight of award recipients' compliance with associated PAPPG requirements.

Workforce Challenges

In FY 2022, NSF implemented the new TIP directorate, as well as a hybrid workforce, which requires support for on-site and multiple off-site employees. NSF's budget increased significantly in FY 2023, and the FY 2024 requested amount is higher still. The CHIPS and Science Act of 2022 also directed NSF to carry out various initiatives and activities that build on existing agency investments. We plan to monitor the overall challenges that result from the use of a hybrid workforce, the creation of the new directorate, and any growth resulting from increased funding for the agency, which present new individual and collective risks to NSF management. For example, we plan to monitor topics such as the adequacy of NSF's management of its information technology infrastructure; use of space at NSF's Alexandria, Virginia headquarters; personnel hiring, supervision, and retention; structure and location of merit review panels; and controls over the new directorate and over the award lifecycle and NSF's assets.

Mid-scale Research Infrastructure

In its FY 2023 Budget Request, NSF requested more than $180 million for mid-scale projects costing between $6 and $100 million. If the total project cost is less than $20 million, the project is funded through the Research & Related Activities account. If the total project cost is more than $20 million, it is funded through the Major Research Equipment and Facilities Construction account. These projects include research instrumentation, equipment, and upgrades to major research facilities or other research infrastructure investments. They address national research priorities, rather than regional or campus level priorities and foster student training and workforce diversity. For example, as mid-scale projects, NSF funded a network of advanced Nuclear Magnetic Resonance spectrometers to enable research at smaller universities and Minority Serving Institutions that lacked prior access to such infrastructure.[2] NSF's *Research Infrastructure Guide*[3] provides guidance for mid-scale projects. According to the *Guidance,* each project is assigned a program officer with primary responsibility for award oversight and project management. In FY 2023, OA plans to review four mid-scale recipients' expenditures and internal controls to determine if the recipients are providing adequate stewardship over federal funds provided for their mid-scale projects. The results of those reviews will help determine if further evaluations of NSF's oversight of its mid-scale projects are warranted.

Audits of Recipients of NSF Grant Funds

Discretionary audits of NSF recipients are an essential part of OA's efforts to protect NSF funds. All statutorily mandated audits and most in-house performance audits focus on NSF's internal operations. Because the bulk of NSF's funding is provided to the academic community via grants and cooperative agreements, robust oversight of that funding is imperative. Audits of NSF recipients determine whether awardees follow the financial and administrative terms and conditions of the awards. They address the highest risk areas at institutions, identifying systemic issues, recapturing misused funds, and making recommendations ensuring proper stewardship of federal funds going forward. These audits also help identify systemic issues resulting from NSF policy and/or guidance, leading to recommendations for NSF to make internal adjustments and improvements.

[2] www.nsf.gov/about/budget/fy2023/pdf/fy2023budget.pdf - Research Infrastructure - 6

[3] www.nsf.gov/pubs/2021/nsf21107/nsf21107.pdf

Historically the OIG has procured audits of NSF recipients to provide this much-needed audit coverage over the recipient community. The coverage of each of these audits at recipients ranged from $9.8 million to $440.0 million from 2018 to 2022. Beyond the findings specific to the institutions being audited, these audits may identify evidence of behavior that could violate criminal or civil laws, which OA would refer to the Office of Investigations. Additionally, these audits may identify inconsistent treatment of similar charges across the academic community, which OA would share with NSF staff so they could address the inconsistencies. The impact of this work is not limited to the entities that are audited: NSF recipients carefully monitor the results of these audits to identify situations where they need to strengthen their own policies and procedures. OA typically uses independent public accounting firms to conduct these audits. OA will also conduct multiple desk review audits at small to medium sized institutions and continue to monitor the quality of Single Audits.

Investigative Impact and Strategic Focus

OIG's Office of Investigations (OI) investigates criminal, civil, and administrative wrongdoing related to NSF programs and operations, including all entities and individuals that receive NSF funds. OI also evaluates and investigates allegations of research misconduct—data fabrication, data falsification, and plagiarism—related to NSF-funded research, and investigates allegations of whistleblower retaliation. OI's vigilance ensures that those who seek or receive NSF research funds are held accountable and serves as a meaningful deterrent to grant fraud, research misconduct, and other wrongdoing.

OI opens investigations based upon consideration of OIG's strategic goals, NSF Management Challenges, the seriousness and magnitude of the offense, the significance of programmatic vulnerability, and the high-risk status of the program or institution.

OIG Investigations resulted in actual recoveries of more than $43.0 million from FY 2017 through FY 2022; conducted nearly 700 investigations in 50 states and the District of Columbia, as well as Puerto Rico, Canada, and Antarctica; and further helped protect NSF research funds through 57 debarments of individuals and entities, 16 voluntary exclusions of individuals, 26 award suspensions, and 17 award terminations. More than 250 other administrative actions were taken. OIG investigators also worked with NSF to remedy numerous administrative practices and procedures to help prevent fraud and continued its leadership and outreach efforts on research security.

<u>Investigative Action on Research Security Threats</u>

OI continues to be a leader in the response to the theft of U.S. federally funded research and development by foreign states that use "talent plans" to exploit the openness of American universities and the federal research enterprise. In FY 2018, OI initiated its first criminal investigations focused on potential fraudulent application for and misuse of NSF funding by members of foreign talent plans. The volume and complexity of these investigations has steadily increased, and they continue to account for approximately half of OI's workload. To meet this challenge, OI has adopted new analytical tools to enhance efficiencies in research and data correlation efforts. OI continues to deliver robust outreach and training to its stakeholders and investigative partners. OI's investigative work on these cases has resulted in award suspensions and terminations, recoveries of NSF funds, and many referrals to the U.S. Attorney's Office for prosecution.

In addition to conducting research security investigations, OI:

- Founded and now serves as co-leader of a Council of the Inspectors General on Integrity and Efficiency (CIGIE) Working Group, which informs and assists investigative colleagues with threat identification, case predication, and best practices in conducting research security investigations.
- Collaborates with the FBI and other investigative partners to conduct outreach to internal and external stakeholders (e.g., grantees, institutions) to explain the risks posed by talent plan membership.
- Conducts outreach and provides education to NSF, which has resulted in the issuance of new or amended agency advisories and policies to address the threat, including an express prohibition of talent plan members serving as federal employees or Intergovernmental Personal Act (IPA) rotators, the requirement that IPA rotators be U.S. citizens, and increased disclosure requirements for researchers seeking NSF funding.
- Supports the operation of a Sensitive Compartmented Information Facility at NSF to enhance the efficiency and effectiveness of research security investigations by facilitating essential communication and coordination with investigative partners across the government.

Investigative action on SBIR/STTR Program Risks

OI has successfully partnered with NSF program managers to improve Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) processes and procedures to reduce the opportunity for fraud to occur. OI also conducts SBIR/STTR-related outreach at NSF awardee workshops, which provides guidance to the small business community on how to properly handle federal funds and the consequences of not following the rules.

OI has also led an OIG community working group focused on fraud in these programs to share best practices and lessons learned. OI's efforts have produced significant programmatic improvements and enhanced understanding throughout the research community. As a result, there has been a substantial decrease in the number of allegations, investigations, prosecutions, and recoveries relating to NSF's SBIR/STTR programs. This great success in identifying and resolving a significant threat to federal research funding has provided a model for our posture towards research security investigations and other emerging threats. Nevertheless, protecting NSF's nearly $600 million portfolio of active SBIR/STTR awards from fraud and abuse remains a significant concern, especially since the size of that portfolio may increase if NSF receives additional funding as a result of the CHIPS and Science Act.

Investigative response to the new NSF Directorate for Technology, Innovation and Partnerships (TIP)

As noted earlier in this document, in FY 2022 NSF established a new TIP directorate to further innovation of emerging technologies and more broadly engage equity holders nationwide. The CHIPS and Science Act of 2022 authorized the directorate. This significant expansion of the NSF mission and initiatives represent a similarly significant increase in the need for investigative oversight to protect federal dollars from fraud and other misconduct. OI will conduct outreach to, and closely monitor developments in, this new directorate to identify emerging risks.

Investigative action on Antarctic sexual assault and harassment risks

OI is partnering with OA in a series of inspections focused on sexual assault and sexual harassment taking place on NSF's Antarctic research stations. OI is examining the existing reporting and investigative processes to identify ways to improve the response to this serious problem.

Support Offices' Actions and Impacts

Office of Management

OIG's Office of Management (OM) directs OIG's financial management, procurement, and administrative functions, and manages the OIG Hotline. Working in partnership with the other OIG divisions, OM guides the strategic vision of the OIG and ensures that all operational needs are met. Critical functional areas include:

Human Capital

Having a strong human capital strategy is vital to the success of any organization. OIG's competitive advantage has long been its highly skilled staff. Expediting the onboarding process, finding ways to improve employee retention, developing leaders from within, and providing specialized training are all OM priorities. Recent adoption of a fully automated Performance Management system has allowed supervisors to spend less time on administrative tasks and more on providing direct guidance to their employees.

Information Technology.

OM strives for continuous process improvement. Investment in IT plays a critical part in achieving that goal. From providing recommendations to senior management on modernization to protecting OIG information systems and data to handling day-to-day hardware and software issues, OM supports all aspects of IT for OIG.

Data Analytics.

A robust data analytics capacity is a core component of OIG's ability to provide effective oversight. To that end, OM employs an in-house forensic accountant to assist OI in managing the large amounts of information that investigators receive through subpoenas and other means. Moreover, OM uses data analytics to streamline internal processes such as procurement oversight and budget execution. These applications yield great efficiency, especially in the new hybrid environment, and allow OIG management to make more informed decisions.

Office of Counsel

The Office of Counsel (OC) consists of the Counsel to the IG and two assistant counsels. OC provides comprehensive legal advice and critical analysis to the IG and all OIG offices, including legal review of externally issued OIG work products and correspondence. OC handles a myriad of subject areas, including audit-related support, ethics, appropriations law, contract law, information disclosure, privacy, federal personnel law, and IG Act authorities. OC also supports the larger IG community through active participation in CIGIE projects and committees. On average, OC handles about 250 actions per year, including legal sufficiency reviews of reports and other externally focused documents, proposed procurements; Freedom of Information Act (FOIA) requests; and legal opinions on various matters. OC attorneys also participate in key meetings and decisions, conduct training, and publish legal updates. This level of involvement enables the office to identify and address potential legal issues and risk areas before they mature.

Immediate Office

The Inspector General's immediate office includes the Chief of Staff. The Chief of Staff handles all matters relating to external affairs, including congressional relations and media contacts.

Government-wide Impact

Though small relative to many other OIGs, NSF OIG continues to make significant contributions to the Inspector General community and the government at large. For example:

- NSF's Inspector General began serving as the Chair of the Council of the Inspectors General for Integrity and Efficiency (CIGIE) in January 2021, having served as the vice chair of CIGIE since 2015.
- NSF OIG has conducted outreach to the federal IG community, provided training to other investigative agencies, and taken the lead to establish and run four IG community working groups to:
  - Prevent fraud within the SBIR/STTR programs;
  - Increase the use of government-wide suspension and debarment as tools to deter and reduce instances of fraud, waste, and abuse;
  - Foster the next generation of senior investigative leaders within the IG community; and
  - Address emerging threats to U.S. national security through efforts by foreign governments to illegally obtain intellectual property and other research.

Financial Discussion

Office of Inspector General

Personnel Compensation and Benefits and General Operating Expenses

(Dollars in Thousands)

	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request	Change over FY 2023 Enacted Amount	Change over FY 2023 Enacted Percent
Personnel Compensation & Benefits[1]	$15,468	$20,249	$22,999	$2,750	13.6%
Travel & Transportation of Persons	203	270	440	170	63.1%
Advisory & Assistance Services[2]	2,463	1,976	2,297	321	16.3%
Rent	-	-	-	-	N/A
Information Technology	230	205	220	15	7.5%
Communications, Supplies, Equipment, and Other Services	523	693	853	160	23.1%
Training	*345*	*255*	*374*	119	46.7%
Other[3]	*110*	*354*	*372*	18	5.0%
CIGIE Assessment[4]	*68*	*84*	*107*	23	27.7%
Total	**$18,888**	**$23,393**	**$26,810**	**$3,417**	**14.6%**
Full-Time Equivalents	72	93	100	7	7.5%

[1] FY 2024 PC&B includes base salary costs and anticipated within grade and promotion increases.

[2] This line includes the costs of the annual financial statements audit and the outsourcing of contracting services.

[3] Other Services includes the cost for Sensitive Compartmented Information Facility (SCIF), which began construction in FY 2022.

[4] In FY 2024, the CIGIE assessment is expected to increase from 0.36% to 0.40% of OIG's appropriation.

FY 2024 Budget Request

Our FY 2024 Budget Request represents a 14.6 percent over the FY 2023 Enacted level. This increase will help ensure that OIG can achieve critical audit and investigative priorities, procure approximately ten audits of NSF recipients, maintain essential FTE, and fund other vital contracts, travel, and training.

Funding at the Budget Request level would enable OIG to retain existing staff and support an additional seven FTE as follows:

- *One criminal investigator* dedicated to OI's Prevention, Planning, Proactive, and Outreach mission. This investigator will help keep pace with rising caseloads and expand oversight of current NSF programs and operations through data analytics and proactive initiatives. This investigator will pressure test known and suspected vulnerabilities and risks inherent to NSF programs, analyze the results of proactive initiatives, and recommend appropriate follow-on actions, such as opening investigations, drafting management advisories, and/or referring matters to the OA.
- *One investigative attorney*. OI investigative attorneys are assigned to civil, criminal, research misconduct, whistleblower retaliation, and other administrative investigations. They also conduct critical outreach to NSF and the research community. This additional investigative attorney will help keep pace with rising caseloads through legal support of investigations and will increase opportunities for referrals to DOJ for civil and criminal prosecutions, provide for expanded investigative oversight of current NSF programs and operations, and contribute to the OI outreach mission.
- *Two auditors* to conduct proactive work in the new TIP Directorate, as well as internal reviews of NSF programs in other high-risk areas. Proactive review of the TIP Directorate is especially important because it is a completely new area for NSF, focused on moving from basic to applied research and expanding public-private partnerships.
- *One data scientist* to establish new, much-needed data science capabilities. Due to the increased utilization of data to advance the mission of OIG, this position will allow the Office of Management (OM) to provide centralized OIG-wide support in this critical area.
- *One human resources specialist* to support growth in FTE across OIG, as well as augment support in staffing and classification, employee relations, performance management, and human capital policy. Having this capability will ensure OIG can develop and execute a much-needed human capital strategy.
- *One personnel psychologist (I/O psychologist)* to lead efforts in recruitment, retention, engagement, and strategic workforce planning.

Inspector General Reform Act Statement

Section 6(g)(1) of the IG Act, 5 U.S.C. app. 3, was amended by the Inspector General Reform Act of 2008 (Pub. L. 110-409) to require a summary statement concerning OIG's annual budget request.

In accordance with this, OIG submits the following summary:

- FY 2024 Budget Request for NSF OIG is $26,81 million.
- The portion for training is $374,000,000.
- The portion for operation of the CIGIE is $107,240.[4]

The portion of the FY 2024 Budget Request for staff training is expected to suffice for all training needs in FY 2024.

[4] This is an estimate of CIGIE's annual membership assessment, which is tied to each member OIG's annual appropriation.

PERFORMANCE AND MANAGEMENT

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

FY 2024 ANNUAL PERFORMANCE PLAN AND FY 2022 PERFORMANCE REPORT

Per the Government Performance and Results Act (GPRA) Modernization Act of 2010,[1] this chapter, together with the Overview, contains basic information about the National Science Foundation's (NSF's) mission and Strategic Plan, as well as NSF's fiscal year (FY) 2024 Annual Performance Plan and FY 2022 Annual Performance Report.

FY 2022-2026 Strategic Plan Framework: Strategic Goals and Objectives

NSF's Strategic Plan for FYs 2022-2026: *Leading the World in Discovery and Innovation, STEM Talent Development, and the Delivery of Benefits from Research*,[2] includes four strategic goals—Empower, Discover, Impact, and Excel—that form the core of the plan. These themes focus on expanding frontiers, engaging people, and delivering solutions. Under each goal are two strategic objectives, which together encompass all areas of agency activity.

FY 2022-2026 Strategic Framework, Strategic Goals, and Objectives

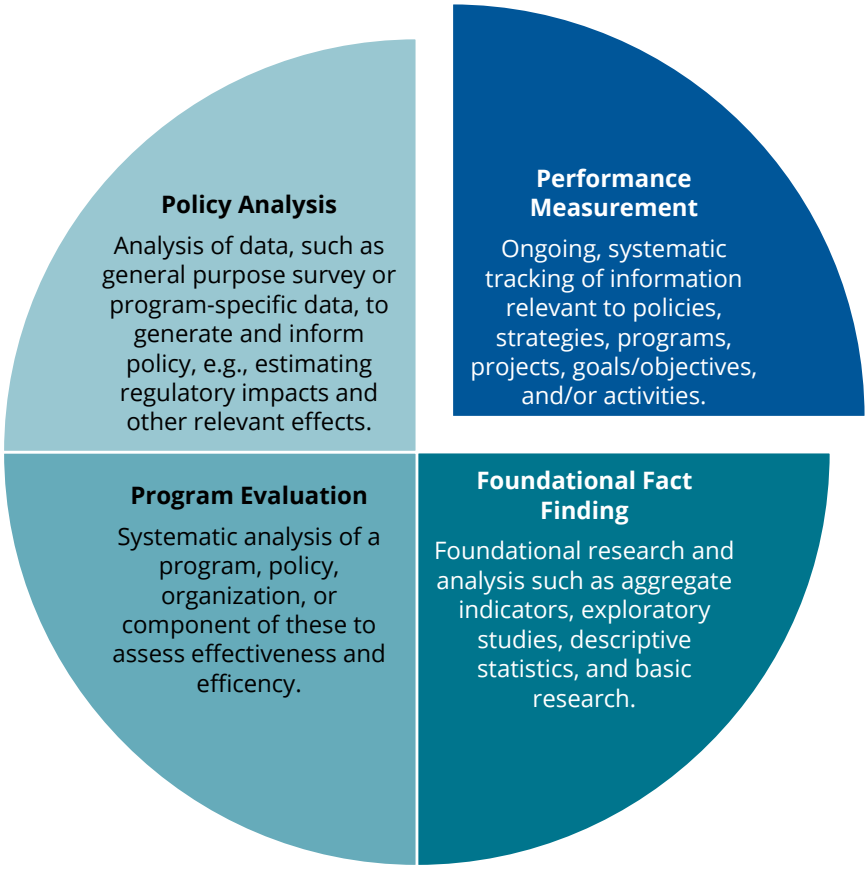
Strategic Goal	Strategic Objective
1. Empower: Empower STEM talent to fully participate in science and engineering	**1.1 Ensure accessibility and inclusivity –** Increase the involvement of communities underrepresented in STEM and enhance capacity throughout the nation.
	1.2 Unleash STEM talent for America – Grow a diverse STEM workforce to advance the progress of science and technology.
2. Discover: Create new knowledge about our universe, our world, and ourselves	**2.1 Advance the frontiers of research –** Accelerate discovery through strategic investments in ideas, people, and infrastructure
	2.2 Enhance research capacity – Advance the state of the art in research practice
3. Impact: Benefit society by translating knowledge into solutions	**3.1 Deliver benefits from research –** Advance research and accelerate innovation that addresses societal challenges
	3.2 Lead globally – Cultivate a global science and engineering community based on shared values and strategic cooperation
4. Excel: Excel at NSF operations and management	**4.1 Strengthen at speed and scale –** Pursue innovative strategies to strengthen and expand the agency's capacity and capabilities
	4.2 Invest in people – Attract, empower, and retain a talented and diverse NSF workforce

[1] The GPRA Modernization Act of 2010 is Public Law 111-352 and is available at: http://www.congress.gov/111/plaws/publ352/PLAW-111publ352.pdf.
[2] NSF's strategic plan is available at https://www.nsf.gov/news/special_reports/strategic_plan/

NSF Performance Management Framework

NSF's Annual Performance Plan and Report builds upon key aspects of the GPRA Modernization Act of 2010 and the Evidence Act.[3] These include Agency Priority Goals and Strategic Reviews, which enable agencies to consider data beyond annual output measures when evaluating agency performance, and a framework outlining four types of evidence. OMB's guidance defines four types of information used for Evidence Building: Foundational Fact Finding, Policy Analysis, Performance Measurement and Program Evaluation.

Components of Evidence
(Presented in OMB M-19-23 and M-21-27)[4]



[3] The Foundations for Evidence-Based Policymaking Act of 2018 (the Evidence Act) is available at https://www.congress.gov/bill/115th-congress/house-bill/4174.

[4] OMB Memorandum M-21-27 "Evidence-Based Policymaking: Learning Agendas and Annual Evaluation Plans" may be accessed at www.whitehouse.gov/wp-content/uploads/2021/06/M-21-27.pdf;
OMB Memorandum M-19-23 "Phase 1 Implementation of the Foundations for Evidence-Based Policymaking Act of 2018: Learning Agendas, Personnel, and Planning Guidance" may be accessed at www.whitehouse.gov/wp-content/uploads/2019/07/M-19-23.pdf

The Annual Performance Plan and Report presented in this chapter includes goals, indicators, and other information that relate directly to these components of evidence:

- *Annual Goals* are included in the "Performance Measurement" category of evidence and answer the question, "What progress is the implemented approach making toward objectives and goals, on key measures and against set targets?"
- *Other Information and Context* includes indicators in the "Foundational Fact Finding" category of evidence and answer the question, "What can we understand about the problem, existing approaches, and the target populations?"
- *Evaluation Highlights* are included in the "Program Evaluation" category of evidence and answer the questions, "To what degree is our implemented approach causing the desired outcomes/impact? How much effect? For whom? Under what conditions?

This multi-faceted framework will help to highlight how science and engineering research and education generate a dynamic set of impacts and benefits, and it will also provide valuable information and insights for strengthening NSF's programs and investments.

Strategic Goal 1, Empower: Empower STEM talent to fully participate in science and engineering

Strategic Objective 1.1: Ensure accessibility and inclusivity. Increase involvement of communities underrepresented in STEM and enhance capacity throughout the nation.

Annual Goal 1.1: Improve representation in the scientific enterprise [Agency Priority Goal][5]

Goal Statement: Increase both the number and proportion of proposals received 1) with principal investigators from groups underrepresented in STEM and 2) from underserved institutions by 10 percent over the FY 2020 baseline.

About this Goal: Among the awards NSF makes annually, the proportion of awards with principal investigators (PIs) from groups underrepresented in STEM is not on par with their representation in the STEM workforce, which in turn is below the relative proportions of the total population. The aim of this Agency Priority Goal (APG) is to improve representation in the scientific enterprise by pursuing actions that will lead to an increase in proposal submissions led by individuals from groups underrepresented in STEM and from underserved communities.

Annual Goal 1.1: Improve representation in the scientific enterprise[6]		FY18	FY19	FY20	FY21	FY22	FY23	FY24
Number of proposals with PIs from groups underrepresented in STEM[7]	Target						14,208	N/A
	Results	N/A	N/A	12,916	13,846	13,127		
Proportion of proposals with PIs from groups underrepresented in STEM	Target						34.1%	N/A
	Results	N/A	N/A	31.0%	32.6%	34.4%		
Number of proposals from underserved institutions[8]	Target						6,786	N/A
	Results	N/A	N/A	6,169	6,623	6,000		
Proportion of proposals from underserved institutions	Target						16.3%	N/A
	Results	N/A	N/A	14.8%	15.6%	15.7%		

Discussion of FY 2022 Result: The FY 2022 target for the APG overall was to establish baselines for

[5] More information on the APG is available at: https://www.performance.gov/agencies/NSF/apg/goal-1/

[6] These FY 2020 baselines, FY 2021 results, and FY 2023 targets were recalculated at the end of FY 2022 to account for improvements in demographic data collection and institutional flags implemented throughout 2021 and 2022. Data as of 12/9/2022.

[7] Investigators in groups underrepresented in STEM include principal investigators who identify as women, members of racial/ethnic minorities underrepresented in STEM, or persons with disabilities.

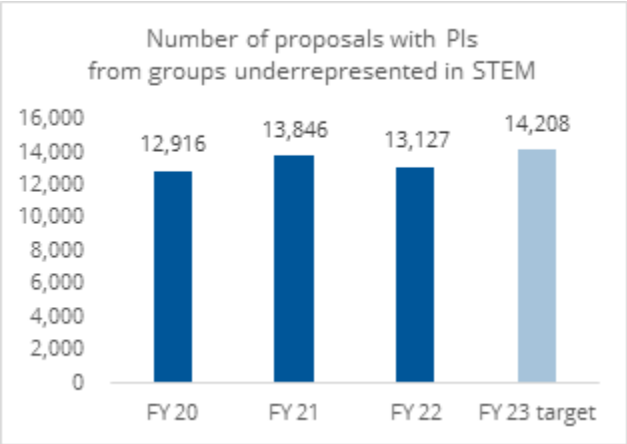
[8] Underserved institutions include awardees receiving less than $50 million in annual federal support for research and development, as measured in Federal obligations, that are either located in Established Program to Stimulate Competitive Research (EPSCoR) jurisdictions or are Minority Serving Institutions (MSIs). Institutions designated as a Minority-Serving Institution for NSF reporting are the following institution types: Disabled Serving, High African American Enrollment, Historically Black Colleges and Universities, High American Indian Serving, Native Alaskan Serving, Native Hawaiian Serving, Pacific Islander, Tribal Colleges, Majority Minority Serving, and Hispanic Serving.

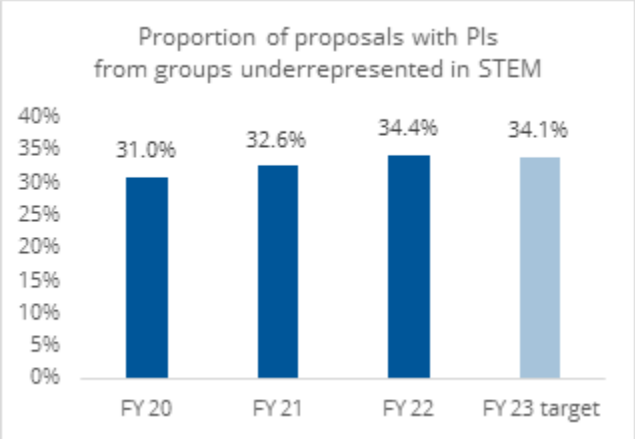
each of the indicators. The FY 2022 target of establishing baselines was met, as presented in the above table and charts below. The FY 2020 baselines, as well as FY 2021 results and FY 2023 targets, were recalculated at the end of FY 2022 to account for improvements in demographic data collection and institutional flags implemented throughout 2021 and 2022. Improved demographic data indicate that at the FY 2020 baseline, NSF was receiving a larger number and proportion of proposals with principal investigators from groups underrepresented in STEM than previously reported. While the absolute number of proposals with principal investigators from groups underrepresented in STEM decreased from FY 2021 to FY 2022, these results reflect an overall decrease in proposals NSF-wide. When factoring in this context, the proportion of these proposals is on track to meet the FY 2023 goal.

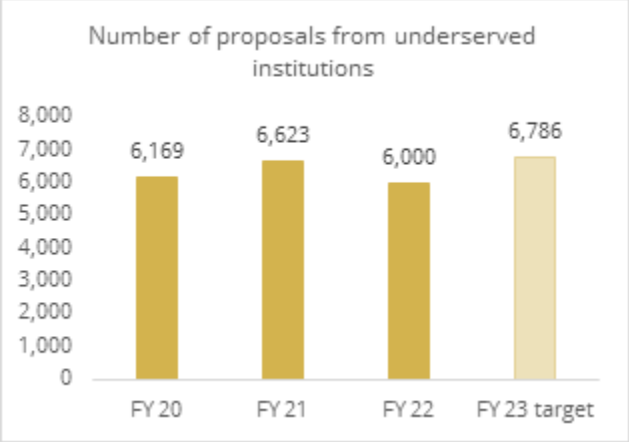
Discussion of FY 2023 Target: The proportion of proposals NSF receives from groups underrepresented in STEM has remained fairly consistent for the last decade or longer.[9] This APG seeks a meaningful increase in the number and proportion of proposals from these groups that is also realistic within the two-year timeframe. With the recalculation of the FY 2020 baselines, the FY 2023 targets, which are a 10 percent increase over the FY 2020 baselines, have increased accordingly. The APG for FY 2024-2025 will be developed in FY 2023.

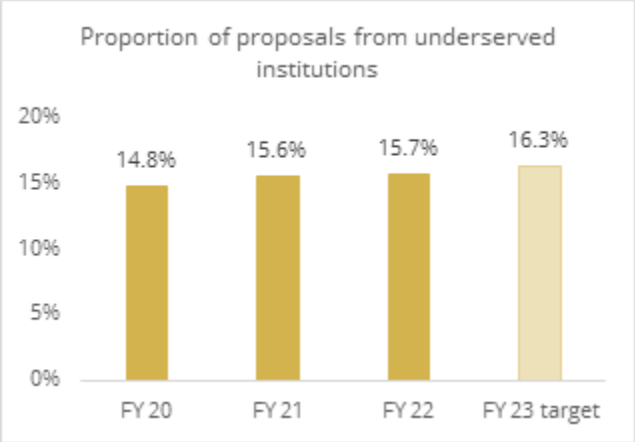
[9] See Figure 9, "Percentage of Proposals from and Awards to Women" and Figure 11. "Percentage of Proposal from and Awards to Researchers from Underrepresented Racial or Ethnics Groups," *Merit Review Process, Fiscal Year 2020 Digest* p. 18, 20. https://www.nsf.gov/nsb/publications/2021/merit_review/FY-2020/nsb202145.pdf

Agency Priority Goal: Improve Representation in the Scientific Enterprise, Key Indicators









Other Information and Context related to Strategic Objective 1.1

The information presented in the tables below provides useful context for this objective and its emphasis on addressing underrepresentation in STEM and expanding the geography of innovation.

NSF Funding to Minority-Serving Institutions: Table 1.1.1 includes the number of, and total funding for, new awards to minority-serving institutions (MSIs).[10] MSIs make considerable contributions to educating and training science leaders, contributing to U.S. economic growth and competitiveness. However, NSF usually receives comparatively fewer grant proposals from, or involving, scholars at, MSIs. NSF is aiming to address these disparities through the APG and though new activities such as GRANTED,[11] which focuses on addressing systemic barriers within the nation's research enterprise by improving research support and service capacity at emerging, developing and underserved research institutions, as well as other ongoing programs and activities devoted to broadening participation.

Table 1.1.1: NSF Funding to Minority Serving Institutions[12]		FY18	FY19	FY20	FY21	FY22
Number of new awards funded to MSIs	Actuals	1,669	1,593	1,673	1,795	1,692
Percent of all new NSF awards	Actuals	14.2%	14.2%	13.7%	15.8%	15.4%
Total funding for new awards to MSIs (millions)	Actuals	$981	$1,020	$1,023	$1,147	$1,201
Percent of all new NSF funding	Actuals	13.2%	13.3%	13.2%	14.1%	14.1%

NSF Funding to Institutions in EPSCOR States: Table 1.1.2 displays the number of, and total funding amounts for, new awards funded to institutions in EPSCoR (Established Program to Stimulate Competitive Research) jurisdictions. These are important indicators for gauging NSF's efforts to expand the geography of innovation, as the EPSCoR program seeks to strengthen STEM capability in jurisdictions that have historically received a smaller share of NSF funding.

Table 1.1.2: NSF Funding to Institutions in EPSCOR Jurisdictions[13]		FY18	FY19	FY20	FY21	FY22
Number of new awards funded to institutions in EPSCoR jurisdictions	Actuals	1,565	1,508	1,687	1,621	1,573

[10] MSIs include the following institution types: Disabled Serving, High African American Enrollment, Historically Black Colleges and Universities, High American Indian Serving, Native Alaskan Serving, Native Hawaiian Serving, Pacific Islander, Tribal Colleges, Majority Minority Serving, and Hispanic Serving.

[11] GRANTED stands for Growing Research Access for Nationally Transformative Equity and Diversity.

[12] Results were generated using the MSI filter for the NSF by the Numbers dashboard as of January 4, 2022. The dashboard may be accessed at https://tableau.external.nsf.gov/views/NSFbyNumbers/NumbersbyState.

[13] Results were generated using the EPSCoR filter for the NSF by the Numbers dashboard as of January 4, 2023. The dashboard may be accessed at https://tableau.external.nsf.gov/views/NSFbyNumbers/NumbersbyState.

Percent of all new NSF awards	Actuals	13.4%	13.4%	13.9%	14.3%	14.3%
Total funding for new awards to institutions in EPSCoR jurisdictions (millions)	Actuals	$820	$909	$974	$1,034	$1,107
Percent of all new NSF funding	Actuals	11.1%	11.8%	12.6%	12.7%	13.0%

In the future, NSF also plans to report on the number of, and total funding amounts for, emerging research institutions.[14]

NSF Funding to Principal Investigators from Groups Underrepresented in STEM: NSF's APG is to increase the number and proportion of proposals submitted by investigators underrepresented in STEM and from underserved institutions as that is the first step to improving representation among these groups. The number of awards to principal investigators from groups underrepresented in STEM is an important indicator that NSF's efforts to increase proposal rates are yielding increased investments in underserved communities.

Table 1.1.3: NSF Awards to Principal Investigators from Groups Underrepresented in STEM[15]		**FY18**	**FY19**	**FY20**	**FY21**	**FY22**
Number of new awards to PIs who identify as women (% of all new awards)	Actuals	3,271 (28%)	3,282 (29%)	3,620 (30%)	3,656 (32%)	3,362 (31%)
Number of new awards to PIs who identify as members of racial/ethnic groups underrepresented in STEM (% of all new awards)	Actuals	914 (8%)	877 (8%)	973 (8%)	1,099 (10%)	976 (9%)
Number of new awards to PIs who identify as persons with disabilities (% of all new awards)	Actuals	156 (1%)	146 (1%)	173 (1%)	147 (1%)	149 (1%)

[14] Section 10002 of the CHIPS and Science Act of 2022 defines Emerging Research Institution as an institution of higher education with an established undergraduate or graduate program that has less than $50,000,000 in Federal research expenditures. The text of the CHIPS and Science Act is available at https://science.house.gov/imo/media/doc/the_chips_and_science_act.pdf.

[15] Data as of 12/7/2022.

Strategic Objective 1.2: Unleash STEM talent for America. Grow a diverse STEM workforce to advance the progress of science and technology.

Annual Goal 1.2: Increase utilization of the Education and Training Application (ETAP)

Goal Statement: Increase both (1) the number of programs leveraging NSF's Education and Training Application (ETAP) to connect individuals (undergraduate, graduates, teachers) with NSF educational opportunities, and (2) the percentage of awards within targeted programs.[16]

About this Goal: Greater use of ETAP will improve NSF's data on participants in NSF-funded education and training programs, improving the agency's ability to make informed program and policy decisions related to Strategic Objective 1.2. By providing a secure online application platform for NSF awards to recruit STEM learners, ETAP collects applicant level information directly from individuals interested in NSF-funded education and training opportunities, such as research experiences, scholarships, and fellowships. As ETAP usage expands, this centralized online infrastructure will not only allow NSF to have complete and detailed information on the characteristics of individuals participating in NSF human capital development programs, but also on those who apply but are not selected, enabling NSF to understand programs' reach and to conduct evaluations with increasing levels of rigor.

Annual Goal 1.2: Increase utilization of the Education and Training Application (ETAP)		FY18	FY19	FY20	FY21	FY22	FY23	FY24
Number of NSF human capital development programs using ETAP[17]	Target						7	10
	Results					4		
Percent of awards using ETAP in Research Experiences for Undergraduates (REU) Program	Target						30%	50%
	Results					14%		
Percent of awards using ETAP in Research Experiences for Teachers (RET) program	Target						30%	50%
	Results					13%		

Discussion of FY 2022 Result: FY 2022 was a baseline year and there was no goal target established.

Discussion of FY 2024 Target: The NSF ETAP system has been used by the Research Experiences for Undergraduates program since its inception. NSF is expanding the use of ETAP to a broader set of NSF-funded opportunities (including fellowships and scholarships) and audiences (such as postbaccalaureate and graduate students, and teachers). NSF plans to undertake efforts to scale up dissemination of ETAP and enhance technology in FY 2023, which will lay the groundwork to onboard more programs into ETAP. NSF is assessing NSF's human capital programs, which will enable a strategic approach focused on promising programs to expand ETAP usage and impact.

[16] More information on ETAP can be found at https://www.nsfetap.org/.

[17] Human capital programs are administered under the Directorate for STEM Education and educate, train, and support discoverers; engage citizen scientists; and foster a well-informed, STEM-literate citizenry prepared to handle rapid technological change and pursue STEM careers.

Other Information and Context related to Strategic Objective 1.2

Although NSF is only one of many federal, non-profit, and private entities involved in growing the STEM workforce, knowledge of general workforce and demographic trends among those in STEM occupations informs the strategies NSF deploys in this area. The NSF-based National Center for Science and Engineering Statistics (NCSES) maintains comprehensive information on data and trends within the U.S. science and engineering workforce. NCSES reports highlight data that are particularly relevant to this Strategic Objective and its emphasis on growing a diverse STEM workforce.

Table 1.2.1 provides overall figures for the U.S. STEM Workforce and shows it has grown over the past several years both in total and as a share of overall U.S. employment.

Table 1.2.1: U.S. STEM Workforce[18]		**2015**	**2016**	**2017**	**2018**	**2019**
Total U.S. employees in STEM occupations (in millions)	Actuals	32.5	33.2	34.1	34.8	36.1
Percent of total US Employees	Actuals	22.0%	22.2%	22.5%	22.7%	23.2%

Table 1.2.2: Demographic composition of the STEM Workforce: 2011 and 2021[19]		**2011**	**2021**
Women	Actual	32.4%	35.2%
White	Actual	73.8%	64.2%
Black or African American	Actual	6.9%	8.6%
American Indian/Alaska Native	Actual	0.3%	0.6%
Hispanic or Latino	Actual	10.7%	14.6%
Asian	Actual	6.9%	10.3%
At least one disability	Actual	3.1%	2.9%

Data on the participation in the STEM Workforce by demographic group was published in the January 2023 report, *Diversity and STEM: Women, Minorities, and Persons with Disabilities*. Based on that report, women made up about one-third of the STEM workforce in 2021, less than their representation in the employed U.S. population (48 percent). In addition, Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives collectively represented 24 percent of the STEM workforce in 2021, though 30 percent of the employed U.S. population.[20]

[18] National Center for Science and Engineering Statistics, *The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers*, 2021. Table SBLR-2, "Employed adults in the United States, by workforce type: 2010-19." The report is available at https://ncses.nsf.gov/pubs/nsb20212/executive-summary

[19] National Center for Science and Engineering Statistics, *Diversity and STEM: Women, Minorities, and Persons with Disabilities,* 2023. Figure 2-2, "STEM workforce ages 18-74, by sex, ethnicity, race, and disability status: 2011 and 2021." The report is available at https://ncses.nsf.gov/pubs/nsf23315/report/the-stem-workforce#growth-in-the-stem-workforce-between-2011-and-2021

[20] National Center for Science and Engineering Statistics, *Diversity and STEM: Women, Minorities, and Persons with Disabilities,* 2023. Figure 1-1, "Characteristics of the U.S. population ages 18-74, by labor force status: 2021." The report is available at https://ncses.nsf.gov/pubs/nsf23315/report/the-stem-workforce#growth-in-the-stem-workforce-between-2011-and-2021

Strategic Goal 2, Discover: Create new knowledge about our universe, our world, and ourselves.

Strategic Objective 2.1: Advance the frontiers of research. Accelerate discovery through strategic investments in ideas, people, and infrastructure.

Annual Goal 2.1: Ensure that Major Facility Infrastructure Investments are on Track

Goal Statement: Ensure program integrity and responsible stewardship of Major Facility investments which have a Total Project Cost (TPC) greater than $100 million. Keep negative cost and schedule variance at or below 10 percent for all (100 percent) of the Major Facility projects in the Construction Stage that are more than 10 percent complete.

About This Goal: Modern and effective research infrastructure is critical to maintaining U.S. international leadership in science and engineering. NSF's major multi-user research facilities (Major Facilities) are transformative in nature, with the potential to shift the paradigm in scientific understanding. Realizing the benefits of new Major Facility investments is based on ensuring their timely completion within budget and planned scope. The use of Earned Value Management (EVM) is required for all Major Facilities in the Construction Stage. Cost and schedule variance are key EVM indicators of whether a project is on track relative to the project plan. For Major Facilities, NSF performs oversight activities of the recipient's EVM System (EVMS) that ensure reliability of these metrics which also reinforces the importance of recipient project management and accountability. Therefore, these metrics provide an indication of the effectiveness of NSF's oversight of projects in construction. This goal only considers the percentage of Major Facility projects under construction that are more than 10 percent complete for which negative cost and schedule variance are both at or below 10 percent. Projects that are less than10 percent complete are not considered because EVM data are less meaningful early in the project.

Annual Goal 2.1: Ensure that Major Facility Infrastructure Investments are on Track		FY18	FY19	FY20	FY21	FY22	FY23	FY24
Major Facility Construction Projects: Percent Meeting Cost and Schedule Targets	Target	100%	100%	100%	100%	100%	100%	100%
	Results	100%	100%	75%	40%	40%		

Discussion of FY 2022 Result: Beginning in FY 2020, the COVID-19 pandemic had a negative impact on projects in construction. In FY 2022, five projects were in the Construction Stage and therefore tracked against this goal: the Vera C. Rubin Observatory (Rubin), Regional Class Research Vessels (RCRV), Antarctic Infrastructure Modernization for Science (AIMS), Compact Muon Solenoid (CMS), and A Toroidal LHC Apparatus (ATLAS). As of September 30, 2022, all five reported being on track for cost performance, and two (Rubin and AIMS) are on track for schedule performance. Going forward CMS and ATLAS will be re-baselined to adjust for delays due to the COVID-19 pandemic,[21] and the schedule for RCRV will be addressed in a revision to plans based on continued impacts of Hurricane Ida on the local labor market. As the poor performance on these metrics were driven by events beyond the control of the project or NSF (COVID-19 pandemic and damage from a major hurricane), NSF has continued to monitor the situation, but no corrective actions were necessary.

[21] AIMS was re-baselined in July 2022.

Discussion of FY 2023 and FY 2024 Targets: In FY 2023, NSF plans to re-baseline the remaining projects in the Construction Stage to adjust for delays caused by the COVID-19 pandemic which will re-set the performance targets and the corresponding EVM metrics.

Consistent with prior years, NSF aims to keep negative cost and schedule variance at or below 10 percent for 100 percent of Major Facilities in the Construction Stage that are more than 10 percent complete. The re-baselining for projects that will occur in FY 2023 will likely lead to improved schedule performance in FY 2024 and beyond.

Other Information and Context related to Strategic Objective 2.1

NSF's Strategic Plan frames the motivation for this goal and objective as follows: "Fundamental research is a capital investment for the nation. Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science."

The three indicators described below are meant to illustrate NSF's contribution to the funding of scientific capital described in the quote above. These are under development, and we plan to include them in future drafts of the annual performance report.

- Number of highly-cited papers (top 10 percent) that reference NSF support.

  Publication of research in peer-reviewed literature is a primary mechanism for disseminating new science and engineering knowledge, enabling the use of discoveries for invention and innovation to expand science and technology output. Citations are an important measure of the impact of publications, and over the past decade, the U.S. has contributed nearly twice as many highly cited articles as would be expected given its overall publication output.[22]

- Number of highly-cited papers (in the top 10 percent) associated with facilities in NSF's major or mid-scale research infrastructure portfolios.

  NSF invests in major facilities and mid-scale infrastructure to open new avenues for research and discovery, and the bibliometric outputs associated with these investments are therefore a useful gauge of their impact.

- Number and geographic diversity of patents, licenses, and startups generated from the Directorate for Technology, Innovation and Partnership (TIP)-supported work.[23]

[22] For more information, see: The State of U.S. Science and Engineering 2022 | NSF - National Science Foundation. https://ncses.nsf.gov/pubs/nsb20221/u-s-and-global-science-and-technology-capabilities

[23] Note: the data for this indicator are anticipated to come from project reports and are not currently available.

Strategic Objective 2.2: Enhance research capability. Advance the state of the art in research practice.

Annual Goal 2.2: Ensure that Mid-Scale Infrastructure Investments are on Track

Goal Statement: Track cost and schedule performance during implementation for Mid-scale Research Infrastructure projects that have a Total Project Cost (TPC) above $20.0 million, are more than 10 percent complete and are using Earned Value Management (EVM) principles.

About This Goal: Modern and effective research infrastructure is critical to maintaining U.S. international leadership in science and engineering. NSF's Mid-Scale Research Infrastructure programs are intended to meet the research community's needs for modern research infrastructure at a scale that is otherwise difficult for individual institutions to acquire. The objectives are to transform scientific and engineering research fields with new infrastructure while simultaneously training early-career researchers in the development, design, implementation, and use of cutting-edge infrastructure. Projects in this portfolio have costs that fall below the $100 million threshold for a Major Facility project but exceed $4.0 million.[24] Use of EVM is optional on Mid-scale Research Infrastructure projects and generally requires more scaling and tailoring when used. For mid-scale projects costing more than $20.0 million to implement, tracking project performance through EVM metrics is one method for ensuring proper NSF oversight and stewardship of Federal funds.

Annual Goal 2.2: Ensure that Mid-Scale Infrastructure Investments are on Track		FY20	FY21	FY22	FY23	FY24
Mid-Scale Research Infrastructure Projects: Percent Meeting Cost and Schedule Targets	Target	Track cost and schedule for all defined projects	Track cost and schedule for all defined projects	100%	100%	100%
	Results	N/A	Achieved	60%		

Discussion of FY 2022 Result: In FY 2022, the performance of six Mid-scale Research Infrastructure projects with total project costs greater than $20 million was tracked using EVM; five of these projects were more than 10 percent complete and therefore constitute the FY 2022 portfolio for this target: the Ice Cube Neutrino Observatory Upgrade (ICNO-U), the Laser Interferometer Gravitational-Wave Observatory A+ Upgrade (LIGO A+), the High Magnetic Field Beamline (HMF), Network for Advanced NMR (NAN) and Grid-Connected Testing Infrastructure for Networked Control of Distributed Energy Resources (DERConnect). All five projects reported being on track for cost performance and three (LIGO A+, HMF and DERConnect) are on track for schedule performance. The other two projects are experiencing schedule delays due to the COVID-19 pandemic.

Discussion of FY 2023 and FY 2024 Targets: Consistent with the approach in FY 2022, NSF aims to keep negative cost and schedule variance at or below 10 percent for Mid-scale Research Infrastructure projects that utilize EVM and are more than 10 percent complete. One additional project (Research Data Ecosystem (RDE)) will pass the 10 percent complete threshold in FY 2023. In FY 2023 and 2024, these projects may begin to achieve target performance as supply chain issues lessen for NAN and ICNO-U transitions to new project management systems with revised EVM data reporting.

[24] Although Mid-Scale Research Infrastructure projects begin at the threshold of $4 million, this goal tracks those most likely to propose using Earned Value Management principles, with total project costs of $20 million or more.

Strategic Goal 3, Impact: Benefit society by translating knowledge into solutions.

Strategic Objective 3.1: Deliver benefits from research. Advance research and accelerate innovation that addresses societal challenges.

Annual Goal 3.1: Grow Partnerships

Goal Statements:

- 3.1a: Increase funding invested from industry and non-profits that NSF programs leverage to support the science, technology, engineering, and mathematics (STEM) enterprise.
- 3.1b: Increase funding invested from other federal agencies that NSF programs leverage to support the science, technology, engineering, and mathematics (STEM) enterprise.

About this Goal: Partnerships are essential to growing research and innovation ecosystems across the country. They further the geography as well as the demography of innovation, key priorities for NSF, the National Science Board, and the U.S. STEM community as a whole. This is a new goal to support the FY 2022-2026 Strategic Plan, and measures NSF's ability to leverage funding from partnerships. It builds on prior efforts including the FY 2020-2021 Agency Priority Goal, "Strategic Engagement in Partnerships," which sought to enhance the impact of NSF's investments through engaging in public and private partnerships, as well as the FY 2018-2019 Agency Priority Goal to, "Expand Public and Private Partnerships." The culmination of these Agency Priority Goals was an NSF-wide partnerships strategy, including outreach, process improvement, and communications aspects. This new iteration of the goal focuses on partnerships that are shaping research directions, cultivating co-design and co-creation of research-based solutions, and accelerating piloting, prototyping, and eventual translation of knowledge gained through NSF's research portfolio to address the Nation's most pressing technological, societal, and economic needs.

Targets and Results: NSF will conduct baselining in FY 2023 and set out-year targets following that process.

Discussion of FY 2022 Result: Not applicable. There was no goal target established for FY2022.

Discussion of FY 2024 Target: The FY 2024 targets will be established following baselining in FY 2023. The measures will include funding resulting from partnerships with (1) industry and non-profits, and (2) other federal agencies, and will be attributed to the year in which they are committed to specific NSF investments.

Other Information and Context related to Strategic Objective 3.1

Partners and Partnerships Counts: In addition to strategically increasing the funding NSF leverages through its partnerships, the agency monitors the number of direct partnerships in which Directorates and Offices engage and the number of distinct partners. In FY 2022, NSF entered into 57 new direct partnerships spanning 31 partners. For the purposes of this metric, FY 2022 new direct partnerships are defined as formal agreements between NSF and other external organizations (federal agency, industry, non-profit, international) resulting in a solicitation, Dear Colleague Letter, or other such funding opportunity issued in FY 2022. The number of partners reported for FY 2022 are therefore a count of the distinct, external organizations associated with these FY 2022 new direct partnerships.

Accelerate innovation that addresses societal challenges: Strategic Objective 3.1, also reflects NSF's commitment to supporting use-inspired research and the translation of research results to the market and society. This strengthens the intense interplay between foundational and use-inspired work, enhancing the full cycle of discovery and innovation. NSF's Strategic Plan emphasizes the importance of engaged research as part of achieving objective 3.1 to, "Advance research and accelerate innovation that addresses societal challenges." Specifically, the plan discusses, "supporting mechanisms and training for researchers in techniques to promote the beneficial uptake of the results of their use-inspired research; and diversifying the research workforce to bring a broader range of perspectives to the generation of research questions."

NSF's I-Corps: This program connects NSF-funded science and engineering research with the technological, entrepreneurial, and business communities, fostering a national innovation ecosystem that links scientific discovery with technology development, societal needs, and economic opportunities. Through I-Corps training, academic researchers can reduce the time needed to translate a promising idea from the laboratory to the marketplace or other relevant societal setting.

Table 3.1.1: Number and diversity of entrepreneurs trained through I-Corps		FY 2017-2018	FY 2019-2020	FY 2021-2022
Total trained	Actuals	1,628	1,928	2,173
Number (percentage) who identified as women	Actuals	338 (21%)	411 (21%)	516 (24%)
Number (percentage) who identified as a member of a group underrepresented in STEM[25]	Actuals	437 (27%)	568 (30%)	683 (31%)

Small Business Innovation Research (SBIR): NSF is one of 11 federal agencies that provides research and development funding to small businesses through the SBIR program. The SBIR program at NSF exists to transform scientific and engineering discoveries into products and services with commercial and societal impact. Further, the program supports participation in innovation and entrepreneurship by women and by socially and economically disadvantaged persons.

[25] Groups underrepresented in STEM include individuals who identify on their I-Corps project proposals as 1) women, 2) race as Black or African American, American Indian, Alaska Native, and/or Native Hawaiian or other Pacific Islander, 3) of Hispanic origin, and/or 4) having a disability.

Table 3.1.2: Number and diversity of small businesses receiving start-up funds through SBIR		2018	2019	2020	2021	2022
Total new awards (Phase 1 and 2)	Actuals	353	421	436	414	359
Number (percentage) of awards to women-owned small businesses	Actuals	72 (20%)	94 (22%)	68 (16%)	82 (20%)	54 (15%)
Number (percentage) of awards to socially and economically disadvantaged small businesses	Actuals	42 (12%)	67 (16%)	42 (10%)	46 (11%)	50 (14%)
Number (percentage) of awards to Historically Underutilized Business Zones (HUBZone)	Actuals	27 (8%)	34 (8%)	19 (4%)	26 (6%)	19 (5%)

In the future, NSF plans to report the number and diversity of fellows supported through the NSF Entrepreneurial Fellowships, which will be awarded for the first time in FY 2023.

Strategic Objective 3.2: Lead globally. Cultivate a global science and engineering community based on shared values and strategic cooperation.

Information and Context related to Strategic Objective 3.2

NSF's commitment to leading globally reflects the critical importance of research and innovation as drivers of future growth. Through its programming, NSF facilitates international scientific collaborations on all seven continents and provides opportunities for researchers to enhance their work through international cooperation. The table below presents data on NSF awards with international collaborations.

Table 3.2.1: International collaborations		FY18	FY19	FY20	FY21	FY22
Number of NSF awards that include collaborations with international partners	Actual		1,368	1,330	1,398	1,211

Evaluation Highlight

Evaluation of International Research Experiences for Students (IRES) program, Office of International Science and Engineering.[26] (Results published in September 2020) The IRES program, managed by the Office of International Science and Education (OISE), supports international research experiences for U.S. undergraduate and graduate students pursuing degrees in science or engineering. This evaluation included a survey of program participants. It found that:

- Just over half of IRES participants were women and about a quarter belonged to an ethnic or racial group underrepresented in STEM.
- Nearly all IRES participants currently hold a postsecondary degree, including half who obtained a graduate degree since participating in IRES. About one quarter of students who participated in IRES as undergraduates subsequently earned a master's degree or doctorate; many of these students received support from NSF's Graduate Research Fellowship Program.
- The majority of IRES participants remained globally engaged after the program ended and are currently members of the STEM workforce.

In addition, most IRES participants reported that the IRES program had shaped their professional goals. Participants often indicated that IRES encouraged them to pursue further education (such as graduate school or postdoctoral studies) or that it helped them solidify their interest in science or engineering.

[26] The report from the evaluation is available at https://nsf-gov-resources.nsf.gov/2022-08/IRES%20Survey%20Analysis%202020.pdf.

Strategic Goal 4, Excel: Excel at NSF operations and management.

Strategic Objective 4.1: Strengthen at speed and scale. Pursue innovative strategies to strengthen and expand the agency's capacity and capabilities.

Annual Goal 4.1: Provide robust and reliable IT services.

Goal Statement: Ensure availability of IT resources for NSF staff and the broader research community. (Uptime)

About This Goal: The availability of information technology (IT) systems is integral to delivering excellent, equitable, and secure Federal services and customer experience. NSF prioritizes availability of IT services, and coordinates downtime for critical maintenance and service releases to minimize disruption. This goal supports the President's Management Agenda pillars of "Strengthening and empowering the Federal workforce," and, "Delivering excellent, equitable, and secure Federal services and customer experience," by ensuring that critical information and IT systems are available to support staff and NSF awardees in their pursuit of NSF's mission. Maintaining reliable, secure operations of NSF's IT systems also supports the Foundation's ability to strengthen at speed and scale and to expand the agency's capacity and capabilities around functions where the use of IT is most critical.

This specific goal measures NSF's success in keeping critical IT systems available aside from pre-planned system outages for maintenance and upgrades (i.e., scheduled downtime). NSF's goal is to meet or exceed 99.6% availability of systems aside from a set number of hours of planned downtime per year. Unexpected downtime due to a system issue or incident will lead to reductions in NSF's IT systems availability percentage.

Annual Goal 4.1 Provide robust and reliable IT services		FY18	FY19	FY20	FY21	FY22	FY23	FY24
NSF IT systems availability (downtime hours)	Target		99.5% (469)	99.6% (469	99.6% (469)	99.6% (469)	99.6% (469)	99.6% (375)
	Result	N/A	99.9%	99.8%	99.8%	99.8%		

Discussion of FY 2022 Result: NSF exceeded the FY 2022 IT systems availability goal, achieving 99.8 percent as actual availability over the target of 99.6 percent within planned downtime of 469 hours. During FY 2022, NSF monitored IT systems availability daily, and worked to quickly identify, address, and remediate any incidents or issues to restore user access to IT systems and functions.

Discussion of FY 2024 Target: Consistent with prior years, NSF aims to maintain or exceed 99.6% availability for IT systems, excluding planned downtime. However, in FY24, NSF has reduced the planned number of downtime hours from 469 hours to 375 hours. Dropping the overall downtime target will result in NSF reducing the time scheduled for system upgrades and planned maintenance from about 9 hours per week to approximately 7.2 hours per week. To ensure consistency with the new target, NSF will carefully plan scheduled downtime for FY 2024.

Other Information and Context related to Strategic Objective 4.1

In order for NSF to strengthen at speed and scale, the agency will need to capitalize on emerging data analytics capabilities and expand its capacity for analysis and knowledge management. NSF's data strategy will outline the paradigm and activities needed to achieve the vision of an agency where everyone is empowered to leverage data and analytics to support NSF's mission.

In support of this work, NSF will track progress against implementation of the data strategy; a specific indicator will be defined in FY 2023 after the strategy is final.

Evaluation Highlight

Understanding the Use and Potential Effects of a No-Deadlines Approach.[27] (Results published in May 2022) NSF has long explored strategies for improving the efficiency of the funding process for its grants programs while maintaining its commitment to research excellence, quality, and fairness. One approach theorized for improving efficiency is eliminating deadlines for proposal submissions.

NSF receives more than 40,000 competitive grant proposals every year. Each proposal undergoes a merit review by external experts selected by NSF program officers who manage the programs to which proposals are submitted. Programs across five NSF directorates and in at least 173 other organizations—including foundations, biotechnology and pharmaceutical companies, universities, and government—use a no-deadlines approach in solicitations.

The empirical literature on no-deadlines approaches to grant solicitations is limited and focused on non-rigorous approaches. The most common outcome of no-deadline approaches reported at NSF is a reduction in proposal volume. This reduction did not appear to be concentrated among specific types of institutions or investigators, but NSF staff voiced interest in further examining outcomes related to the diversity of the portfolio.

[27] The full report on Understanding the Use and Potential Effects of a No Deadline Approach is available at https://nsf-gov-resources.nsf.gov/2022-05/NDL%20Literature%20Review%20Final%20508c_0.pdf.

Strategic Objective 4.2: Invest in people. Attract, empower and retain a talented and diverse NSF workforce.

In order to achieve the objective to attract, empower, and retain a talented and diverse NSF workforce, NSF aims to be a "Top 5" agency among common indicators of employee satisfaction. NSF will also demonstrate its commitment to fostering an inclusive and engaging workplace through a goal to increase employee engagement in diversity, equity, inclusion, and accessibility (DEIA) activities.

Annual Goal 4.2a: Implement the Human Capital Operating Plan

About this Goal: Establishing NSF's 2022-2026 Human Capital Operating Plan is critical to achieving NSF Strategic Objective 4.2: Invest in people. Attract, empower, and retain a talented and diverse NSF workforce. The Human Capital Operating Plan outlines the human capital initiatives and actions that will be undertaken to accomplish two annual performance goals for FY 2024: 1) Rank among the top five mid-size agencies in the annual Best Places to Work rankings published by the Partnership for Public Service; and 2) Rank among the top five CFO Act agencies for Human Capital in the annual benchmarking assessment conducted by GSA.

Goal Statements 4.2a:

- 4.2a(1): Track progress in NSF's Best Places to Work[28] ranking, which assesses employee attitudes about the agency's human capital policies and programs that result in employee satisfaction with their job and the organization as a whole.
- 4.2a(2): Track progress of NSF's benchmarking score for Human Capital Functions, which assesses hiring manager attitudes about the agency's human capital policies and programs that result in the organization's ability to find, hire, develop, engage, retain and reward the people needed to accomplish the agency's mission. Data are collected as part of GSA's Customer Service Survey of Federal employees.

Annual Goal 4.2a Implement the Human Capital Operating Plan		FY18	FY19	FY20	FY21	FY22	FY23	FY24
NSF Ranking in Best Places to Work Among Mid-Size Agencies	Target						Top 5	Top 5
	Results					2nd		
NSF Benchmarking Score for Human Capital Functions among CFO Act/CHCO Agencies	Target						Top 5	Top 5
	Results					1st		

Discussion of FY 2022 Result: NSF's FY 2022 goal was to submit the draft FY 2022-2026 Human Capital Operating Plan to the Office of Personnel Management, which it achieved.

Discussion of FY 2024 Target: NSF's ability to "attract, empower, and retain a talented and diverse NSF

[28] The annual Best Places to Work in the Federal Government rankings, produced by the nonprofit, nonpartisan Partnership for Public Service and Boston Consulting Group, measure employee engagement and satisfaction government-wide as well as at individual departments, agencies and subcomponents. See more information at https://bestplacestowork.org/

workforce" is predicated upon employees' satisfaction with their jobs and their organization – assessed by the annual Federal Employee Viewpoint Survey and reported via the Best Places to Work rankings. It is also predicated upon the satisfaction of NSF supervisors and leadership with the agency's human capital policies, programs, and operations – assessed and reported by GSA's Customer Service Survey of Federal employees. Ranking in the top five of both areas will ensure that NSF is able to curate the workforce needed to achieve the mission and strategic objectives of the agency. The human capital strategies, initiatives, and actions that will be undertaken to achieve the FY 2024 performance targets are found in the agency's Human Capital Operating Plan.

Annual Goal 4.2b: Foster a Culture of Inclusion

Goal Statement 4.2b: Cultivate a workplace environment that proactively supports, engages, and recognizes all members of the workforce.

About this Goal: NSF values diversity and recognizes that a culture of inclusion is a critical driver in achieving its scientific mission. Fostering inclusive work environments and realizing the full potential of the workforce's diversity requires the implementation of thoughtful strategies focused on creating meaningful, sustainable, and measurable change. This holistic approach to diversity and inclusion is supported by Executive Order 14035, "Diversity, Equity, Inclusion, and Accessibility (DEIA) in the Federal Workplace," which requires that federal agencies develop DEIA Strategic Plans, and regularly measure and report on the effectiveness of DEIA initiatives.

Annual Goal 4.2b Foster a Culture of Inclusion		FY22	FY23	FY24
NSF Ranking in Best Places to Work Among Mid-Size Agencies	Target	Increase participation by 10% over FY 2021	Establish three new Employee Resource Groups above FY22 baseline of 3; total = 6 or more ERGs.	To be determined in FY 2023.
	Results	28% increase		

Discussion of FY 2022 Result: NSF places a high premium on diversity, equity, inclusion, and accessibility. Attracting, retaining, and cultivating diverse leaders and staff enhances the organization's collective ability to deliver on its scientific mission. Cultivating a workplace environment that proactively supports, engages, and recognizes all members of the workforce is necessary to fostering a culture of inclusion that engages the talent of the entire NSF workforce and helps empower individuals to realize their full potential.

Establishing additional opportunities for workforce engagement in DEIA activities is key to achieving a diverse and inclusive workplace. As part of its efforts to cultivate a workplace environment that proactively supports, engages, and recognizes all members of its workforce, the Office of Equity and Civil Rights hosted 12 special emphasis program events coordinated with 10 Federally recognized National special observances. Special observances are events and activities designed to enhance cross-cultural and cross-gender awareness and promote harmony, pride, teamwork, and esprit de corps among members of the workforce. They are conducted to recognize the continuous achievements of all Americans to American culture and to increase awareness, mutual respect, and understanding. In accordance with this goal, the focus of these special observances is on encouraging interaction, not just recognition.

The FY 2022 measure for this goal focused on increasing the percent of agency-wide engagement in special emphasis program observances and diversity and inclusion-related activities, which includes agency Employee Resource Group (ERG) membership totals. This measure provides an indication of progress toward the goal fostering a culture of inclusion. The stated target for the measure is a 10 percent increase in the number of participants over the FY 2021 total number. The FY 2021 total number of participants at special emphasis program events and ERG membership was 1,005. The FY 2022 total number of participants at special emphasis program events and ERG membership was 1,288. This represents an increase of 28% in FY 2022.

Discussion of FY 2024 Goal and Target: Establishing additional opportunities for workforce engagement in DEIA activities is critical to achieving a diverse and inclusive workplace. In FY 2023, NSF established a new Chief Diversity and Inclusion Officer role to lead the agency's efforts in workforce engagement around DEIA. One of that position's duties will be to carry out NSF's DEIA Strategic Plan and establish goals to foster a culture of inclusion in the years to come.

Other Information and Context related to Strategic Objective 4.2

Evaluation Highlight

National Science Foundation's Rotator Study.[29] (Results published in June 2022) This study focused on NSF's use of the Intergovernmental Personnel Act (IPA), which allows for scientists, engineers, and educators from other government agencies, non-profit organizations, and colleges and universities to join the National Science Foundation (NSF) as temporary staff members. The study found that the geographic diversity of IPAs has been increasing over time, in keeping with NSF's efforts to expand knowledge in science, engineering, and learning geographically.

In addition, the increasing percentage of IPAs from institutions other than doctorate institutions suggests an increasing diversity in the background of IPAs beyond the traditional high research universities, to include those employed at institutions that grant only bachelor's degrees or bachelor's and master's degrees as well as institutions outside the traditional academic institution universe. While reducing the cost of the IPA program to the Foundation is a goal in itself, requiring cost sharing in the IPA program may also help the Foundation strengthen partnerships between NSF and institutions.

[29] The report for NSF's Rotator Study is available at https://nsf-gov-resources.nsf.gov/2022-06/IPA%20Rotator%20Study_508c.pdf.

Cross-cutting Areas

Cross-cutting Annual Goal

Annual Goal 5.1: Make Timely Proposal Decisions

Goal Statement: Inform applicants whether their proposals have been declined or recommended for funding within 182 days, or six months, of deadline, target, or receipt date, whichever is later.

About This Goal: Time to decision or "dwell time" is the amount of time that passes between receipt of a proposal and notification to the principal investigator about the funding decision. At the time of this goal's establishment in the early 2000s, one of the most significant issues raised in customer satisfaction surveys was the time it took NSF to process proposals, with only around 50 percent of proposals receiving responses within 6 months of submission or deadline. Too long a time period inhibits the progress of research as it delays the funding process, but too short a time period may inhibit review quality, and some complex proposals go through a multi-stage review and approval process that requires longer than six months. Since this goal was introduced, NSF's response times have improved. In choosing a target, NSF seeks to strike a balance between the need of the principal investigators for timely action and the need of NSF for a credible and efficient merit review system. For a number of years, the dwell time target was 70 percent. In 2015, the target was raised to 75 percent; however, as the data in the table below show, as the complexity of programs and proposals has increased, with more interdisciplinary projects proposed, the 75 percent goal is no longer realistic. Therefore, the target for FYs 2023 and 2024 is being returned to 70 percent.

Annual Goal 5.1: Make Timely Proposal Decisions		FY18	FY19	FY20	FY21	FY22	FY23	FY24
Percent of proposals declined or recommended for funding within 182 days or six months.	Target	75%	75%	75%	75%	75%	70%	70%
	Result	72%	61%	68%	65%	66%		

Discussion of FY 2022 Result: NSF did not meet the target in FY 2022. In recent years, the growth in the complexity of proposals has resulted in additional time for review, and the 75 percent target has become difficult to achieve.

Discussion of FY 2024 Target: Reflecting the changing nature of proposals and consistent with recent changes to help principal investigators avoid conflicts of commitment, a target of 70 percent has been adopted for FY 2023 and FY 2024. Specifically, NSF has added a step to the award process in which potential awardees are asked to submit updated statements of current and pending support prior to the finalization of an award recommendation, which lengthens the award process.

Other Crosscutting Information and Context

A principal mechanism for cross-cutting activities at NSF is the use of NSF-wide investments. For FY 2023 and FY 2024, NSF will monitor the extent to which NSF is able to meet its annual funding targets for key NSF-wide investments. The percentage of the annual targeted funding that is obligated by the end of the year is an indication of NSF's effectiveness in moving through the program investment process and ensuring that key investments are implemented and on track. NSF will identify themes in FY 2023 related to key areas of interest for NSF and the Administration and will track annual obligations against these key areas.

Revised or Retired Measures

NSF retired the measure to Ensure Key Program Investments are on Track by fully obligating funds from the American Rescue Plan Act, as those funds expired in FY 2022. NSF achieved its goal with 100 percent of American Rescue Plan funds obligated by the end of FY 2022.

Other Information

Data Verification and Validation

It is NSF's practice to follow Government Accountability Office (GAO) guidance and engage external contractors to conduct an independent validation and verification (V&V) review of its annual performance information, data, and processes. The guidance from GAO indicates that agencies should "…describe the means the agency will use to verify its performance data…" and "…provide confidence that [their] performance information will be credible."[30] In FY 2022, NSF contracted with Nexight Group to perform the independent verification and validation. Nexight assessed the validity of NSF data and verified the reliability of the methods used to collect, process, maintain, and report that data. Nexight's FY 2022 report concluded that, "Overall, the Nexight Team verifies that NSF relies on sound data collection practices, internal controls, and manual checks of system queries to ensure accurate performance reporting. Based on the V&V assessment, the Nexight Team has confidence in the systems, policies, and procedures used by NSF to calculate results for its performance measures."[31]

[30] GAO, The Results Act: An Evaluator's Guide to Assessing Agency Annual Performance Plans, GAO/GGD-10.1.20 (Washington, D.C.: April 1998), pp. 40-41.

[31] Nexight Group with Energetics Incorporated, *National Science Foundation Performance Measurement Verification and Validation Report, Fiscal Year 2022 Report*. December 2022.

FY 2022 Strategic Objective Progress Update

In FY 2022, NSF conducted its first assessment of the eight Strategic Objectives in its FY 2022-2026 Strategic Plan, in response to the requirement of the GPRA Modernization Act of 2010. This review informed NSF's classification among three categories of the level of progress made towards select Strategic Objectives: noteworthy progress, in need of focused improvement, or neither (making typical progress).

Table of FY 2022 Strategic Objective Rankings

2022-2026 Strategic Goals	2022-2026 Strategic Objectives	Agency Ranking
Empower: Empower STEM talent to fully participate in science and engineering	1.1 Ensure accessibility and inclusivity. Increase involvement of communities underrepresented in STEM and enhance capacity throughout the nation.	Focus Area for Improvement
	1.2 Unleash STEM talent for America. Grow a diverse STEM workforce to advance the progress of science and technology.	Noteworthy Progress
Discover: Create new knowledge about our universe, our world, and ourselves.	2.1 Advance the frontiers of research. Accelerate discovery through strategic investments in ideas, people, and infrastructure.	Not ranked in FY 2022
	2.2 Enhance research capability. Advance the state of the art in research practice.	Not ranked in FY 2022
Impact: Benefit society by translating knowledge into solutions.	3.1 Deliver benefits from research. Advance research and accelerate innovation that addresses societal challenges.	Noteworthy Progress
	3.2 Lead globally. Cultivate a global science and engineering community based on shared values and strategic cooperation.	Not ranked in FY 2022
Excel: Excel at NSF operations and management.	4.1 Strengthen at speed and scale. Pursue innovative strategies to strengthen and expand the agency's capacity and capabilities.	Not ranked in FY 2022
	4.2 Invest in people. Attract, empower, and retain a talented and diverse NSF workforce.	Not ranked in FY 2022

Process Overview

This report provides a summary of the FY 2022 Strategic Review Process conducted by NSF in response to the requirement of the GPRA Modernization Act 2010 Section 1116(f). OMB Circular A-11 (260.2) specifies that: *"Annually, agency leaders should review progress on each of the agency's Strategic Objectives established by the agency Strategic Plans and updated annually in the Annual Performance Plan. These reviews should inform strategic decision-making, budget formulation, and near-term agency actions, as well*

as preparation of the Annual Performance Plan and Annual Performance Report." The process described below was developed utilizing the guidance in sections 260.8-260.25 of OMB Circular A-11.

Two Components: Topic Reviews and Dashboard Development

NSF's Strategic Review Process uses the results of existing assessments, evaluations, and reports as well as other sources of evidence. Internal dashboards for each of the Strategic Objectives in the NSF Strategic Plan are updated. These Objectives are crosscutting and do not mirror NSF's organizational structure, and the major strategic issues often facing NSF seldom fit within a single Strategic Objective, so NSF also scans the environment for topics and conducts crosscutting topical reviews as necessary. These are performed as a cross-agency activity, without concentrating on single organizational units or individual programs.

Both elements of the process draw upon comprehensive assessment processes that already are in use at NSF. For example, the annual Merit Review Report to the National Science Board describes all annual outputs. The Committee of Visitors (COV) process, in which external experts assess NSF programmatic activities approximately every four years, is also comprehensive. Instead of duplicating these efforts, the Strategic Review process at NSF complements them by making use of the information they generate when appropriate (e.g., reviewing their recommendations or using their data in a topic review, and using them as sources of evidence for a dashboard).

FY 2022 Process Adjustments

After using the Strategic Review resources to support the development of the Strategic Plan in 2021, NSF returned to the process described above in 2022. NSF performed two topical reviews in FY 2022. One was on the development of the GRANTED program and identified three opportunities for action or improvement. The other was on divestment of major facilities and identified six opportunities for action or improvement.

FY 2022 Strategic Objective Rankings Justification

Noteworthy Progress

Over the past year, NSF has continued progress made in prior years to address longstanding disparities in the STEM workforce, in support of Strategic Objective 1.2 to grow a diverse STEM workforce to advance the progress of science and technology. In addition, NSF has recently made strides in delivering benefits from research in support of Strategic Objective 3.1 to advance research and accelerate innovation that addresses societal challenges, the most notable example being the establishment of the Directorate for Technology, Innovation and Partnerships (TIP) in March 2022. NSF rated both these objectives as attaining noteworthy progress in FY 2022.

Focus Area for Improvement

NSF ranked Objective 1.1, Ensure accessibility and inclusivity, as a focus area for improvement. This decision reflects the evolution and the elevation in the awareness and understanding of issues related to diversity, equity, inclusion, and accessibility (DEIA) over the past two years at a national level as well as at NSF and within the communities NSF serves. NSF has taken steps to address longstanding disparities throughout the STEM enterprise, but is designating this as a focus area to underscore the importance of taking a coordinated, agency-wide approach in response. This, along with notable successes underpinning the ranking of 1.2 as Noteworthy Progress, is more fully described in NSF's most recent response to the OIG Management Challenge, "Increasing Diversity in Science & Engineering Education and Employment." NSF's response to this challenge was provided to the OIG in

Fall 2021 and published as an appendix to the Annual Financial Report in November 2021, with an update on this challenge published in Fall 2022.

Management Challenges Progress Report

In October 2021, the OIG identified eight areas representing challenges for NSF in FY 2022: (1) Increasing Diversity in Science & Engineering Education and Employment, (2) Overseeing the United States Antarctic Program (USAP), (3) Overseeing Grants in a Changing Environment, (4) Managing the Intergovernmental Personnel Act Program, (5) Overseeing Major Multi-User Research Facilities, (6) Mitigating Threats Posed by Foreign Government Talent Recruitment Programs, (7) Mitigating Threats Posed by the Risk of Cyberattacks, and (8) Managing Transformational Change.[32]

Management's report on the significant activities undertaken in FY 2022 to address these challenges is included in Appendix 2B: Management Challenges – NSF's Response of this Agency Financial Report (AFR).[33] The report also discusses activities planned for FY 2023 and beyond. The following are highlights of the agency's significant actions and planned next steps to address the FY 2022 OIG Management Challenges.

Other Information

Strategies and Collaborations

No one standard strategy is used across NSF for achievement of goals. Goal leaders at NSF choose strategies tailored to their stakeholders' needs and their institutional capabilities. NSF goals often involve testing the impacts of new activities or new approaches to existing activities, so feedback mechanisms are built in. Use of analysis, evidence, and evaluation findings is also at the discretion of each individual goal leader, as is the decision to collaborate with other agencies or external entities or to invest in contract support for their activities. Each quarter, NSF senior leadership reviews progress towards all performance goals of the agency, including the Agency Priority Goals, in a data-driven review meeting led by the Chief Operating Officer and Performance Improvement Officer.

Committee of Visitors Reviews

NSF relies on the judgment of external experts to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. Committee of Visitor (COV) reviews provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations; and (2) program-level technical and managerial matters pertaining to proposal decisions.

COV reviews are conducted at regular intervals of approximately four years for programs and offices that recommend or award grants, cooperative agreements, and/or contracts and whose main focus is the conduct or support of NSF research and education in science and engineering. Lists of recent COVs are available at: https://www.nsf.gov/od/oia/activities/cov/

Alignment of Human Capital Efforts with Organizational Performance

[32] Management Challenges for the National Science Foundation in Fiscal Year 2022 can be accessed at https://oig.nsf.gov/sites/default/files/reports/2022-10/Management-Challenges-NSF-FY-2022_0.pdf

[33] Appendix 2B is available at https://www.nsf.gov/pubs/2023/nsf23002/pdf/08-chap3-appendices.pdf

To drive individual and organizational performance, NSF requires that the performance plans of all employees, executives, and the general workforce contain individual goals aligned with the agency's mission and strategic goals. NSF provides training and makes tools and templates available for all supervisors and employees on linking performance plans to agency mission, as well as providing assistance and training on the policies, processes, requirements, and timeframes for the development of performance plans and appraisals.

NSF also directly aligns its strategic human capital and accountability efforts to the agency goals identified in the NSF Strategic Plan. The Annual Performance Plan for FY 2024 incorporates human capital goals established in the agency's Human Capital Operating Plan, which is updated annually. The performance goals in the plan cascade from NSF's 2022-2026 Strategic Plan; most notably, Strategic Goal 4: Excel and Strategic Objective 4.2: Invest in people – attract, empower, and retain a talented and diverse NSF workforce. The agency continues to use its HRStat[34] program to report on and articulate the nexus between NSF's strategic goals and objectives, including annual goals, and human capital initiatives at the agency. Senior leaders are briefed quarterly regarding the status of annual performance goals and the human capital initiatives aligned to those goals.

Lower-Priority Program Activities

The President's Budget identifies the lower-priority program activities, as required under the GPRA Modernization Act, 31 U.S.C. 1115(b)(10). The public can access the volume at: www.whitehouse.gov/omb/budget.

Use of Non-Federal Parties

No non-federal parties were involved in preparation of this Annual Performance Report.

Classified Appendices Not Available to the Public

None

[34] HRStat is a strategic human capital performance evaluation process that identifies, measures, and analyzes human capital data to inform the impact of an agency's human capital management on organizational results with the intent to improve human capital outcomes. For more information, see: https://www.opm.gov/policy-data-oversight/human-capital-management/hr-stat/#url=Overview

GAO-IG Act Exhibits

Pursuant to P.L. 115-414, the Good Accounting Obligation in Government Act (GAO-IG Act), the following three tables report on unresolved NSF OIG and U.S. Government Accountability Office (GAO) recommendations open for more than one year and their associated statuses as of February 1, 2023.

Open GAO Recommendations, as of February 1, 2023

GAO Report Number	Report Title (Date)	GAO Recommendation	Timeline to Implement
GAO-21-130	Federal Research: Agencies Need to Enhance Policies to Address Foreign Influence (12/17/2020)	Recommendation 9: The Director of the National Science Foundation should include a definition on non-financial conflicts in their agency policies, such as the one developed by OSTP, and address these conflicts, both foreign and domestic.	The National Science Foundation (NSF) has implemented this recommendation. NSF was pleased to coordinate with Congressional colleagues so that a definition and prohibition of malign foreign talent recruitment programs are included in the 2022 CHIPS and Science Act. NSF has had well-defined conflict of interest policies for many years and the agency does not differentiate between foreign and domestic conflicts of interest. However, NSF is committed to communication to the community by the NSF Director and Chief of Research Security Strategy and Policy (CRSSP) regarding research security risks including concerns about malign foreign talent recruitment programs. The NSF Director and CRSSP have communicated frequently over the past year with groups such as APLU, AAU, and COGR regarding such risks. Additionally, NSF co-chaired the NSTC research security subcommittee that released NSPM-33 Implementation Guidance in January 2022 to harmonize disclosure requirements on potential conflicts of interest and commitment with other federal agencies.
GAO-21-152	Data Governance: Agencies Made Progress in Establishing Governance, but Need to Address Key Milestones (12/16/2020)	Recommendation 9: The Director of the National Science Foundation should direct the Chief Data Officer to conduct a gap analysis between the current staff's skills and the skills the agency requires, and establish a baseline performance plan to close the identified data skills and literacy gaps.	NSF is making progress to complete this action but has not completed all activities. We are working to have an updated timeline by Q3 FY23. NSF has completed the following Evidence Act activities: • Established an active governance structure • Met strategic planning deadlines (Title I) • Progressed in data infrastructure planning and data use (Title II) • Promoting open data (Title III) NSF is currently addressing the Evidence Act skill gap activities.

GAO-IG Act Exhibits

GAO Report Number	Report Title (Date)	GAO Recommendation	Timeline to Implement
GAO-20-187	Sexual Harassment in STEM Research: Agencies Have Taken Actions, but Need Complaint Procedures, Overall Plans, and Better Collaboration (3/19/2020)	Recommendation 15: The Director of NSF should establish goals and an overall plan to assess all of the agency's sexual harassment prevention efforts for their university grantees, including methods to regularly monitor and evaluate its sexual harassment prevention policies and communication mechanisms (e.g. Title IX or sex discrimination websites).	The National Science Foundation expects to implement this recommendation in FY 2023. The evaluation of NSF's harassment prevention efforts focused on the Harassment Notification Term and Condition and the Foundation's expectations regarding conference and travel awards. As previously reported to GAO, this evaluation is being conducted in several phases. The first phase of this evaluation was completed in FY 22, and its findings have provided useful information for the next phase of the evaluation. NSF is now working with the evaluation team on the planning, development, and deployment of surveys and one-to-one interview sessions with a pool of NSF awardee organizations' Title IX Coordinators, Authorized Organizational Representatives, and Principal Investigators. The surveys and interviews are expected to gather more detailed information of on the experiences of these officials with their organizations' implementation of the Harassment Notification Term and Condition and related policies for NSF-funded conferences and travel to conferences.
GAO-20-81	Federal Research: Additional Actions Needed to Improve Public Access to Research Results (11/21/2019)	Recommendation 7: The Director of the National Science Foundation should fully implement plans to ensure appropriate agency-funded research data are readily findable and accessible to the public.	NSF has implemented this recommendation. In December 2021, NSF implemented NSF-PAR version 2.0 which enables the system to accept dataset records and ensure agency-funded research data are readily findable and accessible to the public. This process is continuing to evolve and NSF-PAR 2.5 is being implemented, and scheduled for completion by end of CY 2023.

GAO Report Number	Report Title (Date)	GAO Recommendation	Timeline to Implement
GAO-20-81	Federal Research: Additional Actions Needed to Improve Public Access to Research Results (11/21/2019)	Recommendation 37: As the Subcommittee on Open Science moves forward, the National Science Foundation co-chair, in coordination with other co-chairs and participating agencies, should take steps to fully implement leading practices that enhance and sustain collaboration.	NSF has implemented this recommendation. Following the GAO recommendations, the NSF co-chair in coordination with the other co-chairs and participating agencies rebuilt and restructured the subcommittee's workplan. The new workplan highlighted high-value action categories and clarified relationships between actions and deliverables. The subcommittee used the workplan to organize its activities in calendar years 2020 and 2021, and the SOS continues to move forward with a newly organized workplan that advances updates in CY 2022 to OSTP's goals (advance equity, maximize accessibility and utility, revolutionize infrastructure, enhance ease and rewards) for open science. NSF continues to have active participation in SOS subgroups, including in the new Year of Open Science group for CY 2023.
GAO-19-227	National Science Foundation: Cost and Schedule Performance of Large Facilities Construction Projects and Opportunities to Improve Project Management (3/27/2019)	Recommendation 1: The Director of NSF should assess the agency's large facilities oversight workforce to identify any project management competency gaps, develop a plan to address any gaps and time frames for doing so, and monitor progress in closing them.	NSF will complete implementation of this recommendation once internal standard operating guidance is revised in 2023 to incorporate the latest PMIAA competency model and establish the cadence for future staff self-assessments. As part of the implementation of the Program Management Improvement and Accountability Act (PMIAA), NSF has developed a competency model for staff overseeing major facilities and mid-scale research infrastructure, completed an initial gap analysis through self-assessment and supervisor surveys, evaluated available training options to identify future needs, and revised position descriptions. A new Course Curriculum Tool specific to PMIAA was made available to NSF staff in May 2022. GAO will continue to monitor NSF's progress on PMIAA implementation during their 2023 engagement.

GAO-IG Act Exhibits

GAO Report Number	Report Title (Date)	GAO Recommendation	Timeline to Implement
GAO-18-656	Science and Technology: Considerations for Maintaining U.S. Competitiveness in Quantum Computing, Synthetic Biology, and Other Potentially Transformational Research Areas (9/26/2018)	Recommendation 4: As the QIS Subcommittee moves forward, the National Science Foundation co-chair, in coordination with other co-chairs and participating agency officials, should take steps to fully implement leading practices that enhance and sustain collaboration.	NSF has implemented this recommendation. With the amendment to the NQI that was created as part of the revised NDAA legislation, NSF is now a member of the newly-authorized ESIX subcommittee and is coordinating with the other ESIX agencies to focus on addressing topics related to security that are impacted by QIS. In addition to the three existing reports from the Subcommittee that were referred to in last year's report, the SCQIS has now released a fourth report on "Bringing Quantum Sensors to Fruition." The working group that assembled this report was co-chaired by the NSF, DHS, and NIH. On December 6, 2022, OSTP sponsored a joint meeting between the directors of the NSF, DOE, and DOD centers to share progress and experiences. The National Quantum Initiative Advisory Committee called for in the NQI act has now been announced and held its first meeting on December 16, 2022.
GAO-18-656	Science and Technology: Considerations for Maintaining U.S. Competitiveness in Quantum Computing, Synthetic Biology, and Other Potentially Transformational Research Areas (9/26/2018)	Recommendation 5: As the Interagency Working Group on Synthetic Biology moves forward, the Director of the National Science Foundation, in coordination with participating agency officials, should take steps to fully implement leading practices that enhance and sustain collaboration.	NSF has implemented this recommendation. NSF's leadership of the Interagency Synthetic Biology Working Group, participation in the coordinated response to activities associated with the implementation of the Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe and Secure American Bioeconomy, and NSF's leadership in collaborating across agencies to address directives set forth in Title IV- Bioeconomy Research and Development Initiative set forth in the Chips and Science Act of 2022 are illustrative of NSF's implementation of leading practices that enhance and sustain collaboration.

Open OIG Recommendations – Internal Audits

OIG Report Number	Audit Report Title (Date)	OIG Recommendation	Status as of 2/1/2023[1]	Timeline to Implement
17-2-009	Audit of Preservation of Electronic Records and Cooperation with Congressional Requests (7/6/2017)	Recommendation 2) Develop policies, procedures, and controls to capture and retain work-related text messages, social media posts, and electronic records created on government and non-government accounts to meet NARA requirements.	Resolved and Open	9/30/2023
19-2-003	NSF Could Improve its Controls to Prevent Inappropriate Use of Electronic Devices (12/21/2018)	Recommendation 4) Ensure that all existing NSF-owned mobile devices (iPhones and iPads) are enrolled in AirWatch.	Resolved and Open	9/30/2023
21-2-004	EPSCoR: Ensuring NSF Awardees Complying with NSF/Federal Requirements (8/13/2021)	Recommendation 3) Clarify NSF's guidance on participant support costs associated with EPSCoR-funded education, outreach, and diversity programs.	Resolved and Open	5/31/2023
22-6-003	Remote Versus In-Person Merit Review Panels (1/20/2022)	Recommendation 2) Identify and implement solutions to improve merit review panelist demographic data.	Resolved and Open	3/21/2023

1/ Resolved recommendations reflect those where OIG and NSF agree on corrective actions, but the implementation of those corrective actions is ongoing.

Open OIG Recommendations – External Audits

As of February 1, 2023, there were 440 open NSF OIG recommendations stemming from audits of awardees (external audits). These recommendations spanned 23 audits with over $6.9 million in questioned costs.

- **Unresolved:** 322 open recommendations across 15 audits were unresolved as of February 1, 2023, reflecting nearly $4.2 million in questioned costs.
- **Resolved:** 118 open recommendations across 8 audits were resolved, meaning that NSF and OIG agree on the corrective actions, but implementation is ongoing.
    - These audits reflect nearly $2.8 million in questioned costs, of which $223,525 have been disallowed, and $28,889 have been allowed.

Open OIG Recommendations – External Audits (Unresolved as of February 1, 2023)

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
19-1-010	University of Maryland College Park (5/2/2019)	1.1) Resolve the $101,937 in questioned costs related to unreasonable and unallocable payroll transfers near award expiration.	$101,937	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	1.2) Direct UMD to strengthen administrative and management controls and processes over payroll expenditures.	$0	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	2.1) Resolve the $79,956 in questioned costs for equipment purchases near award expiration.	$79,956	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	2.2) Direct UMD to strengthen administrative and management controls and processes related to the review of expenditures charged to Federal awards.	$0	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
19-1-010	University of Maryland College Park (5/2/2019)	3.1) Resolve the $43,710 in questioned costs for unsupported charges for data collection services, conference fees, & equipment purchases.	$43,710	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	3.2) Direct UMD to provide support that it has repaid the $1,918 of unsupported questioned costs for equipment purchased.	$1,918	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	3.3) Direct UMD to implement policies and procedures to ensure NSF approves changes to the scope of work regarding subcontractors and maintain source documentation to properly support charges to Federal awards.	$0	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	4.1) Resolve the $37,812 in questioned costs for equipment and supply purchases near or after award expiration date, and direct UMD to repay or otherwise remove the sustained questioned costs from its NSF awards	$37,812	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	4.2) Direct UMD to strengthen administrative and mgt controls and processes over equipment & supply expenditures near the end of an award.	$0	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	5.1) Resolve the $31,697 in questioned costs for lab & computer equipment allocations, and direct UMD to repay or otherwise remove the sustained questioned costs from its NSF awards.	$31,697	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
19-1-010	University of Maryland College Park (5/2/2019)	5.2) Direct UMD to strengthen administrative and mgt controls over allocation of lab & computer equipment costs benefitting multiple awards or projects.	$0	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	6.1) Resolve the $24,559 in questioned travel costs, and direct UMD to repay or otherwise remove the sustained questioned costs from its NSF awards.	$24,559	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	6.2) Direct UMD to strengthen administrative and mgt controls and processes over travel costs, including identifying guidelines for determining reasonableness of lodging costs	$0	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	7.1) Resolve the $13,905 in questioned costs for unreasonable travel and equipment cost transfers	$13,905	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	7.2) Direct UMD to strengthen administrative and management policies and procedures relating to travel & equipment cost transfers.	$0	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	8.1) Direct UMD to provide support that is has repaid the $12,659 of questioned indirect costs.	$12,659	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	8.2) Direct UMD to strengthen administrative and mgt controls and processes for reviewing and approving indirect costs for equipment purchases charged to NSF awards.	$0	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
19-1-010	University of Maryland College Park (5/2/2019)	9.1) Resolve the $8,955 in questioned costs for unallowable public relation costs.	$8,955	4/30/2023
19-1-010	University of Maryland College Park (5/2/2019)	9.2) Strengthen administrative and mgt controls and processes to ensure unallowable public relation cost are not charged to NSF awards.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	1.1) Resolve the $169,950 in questioned consulting and subaward costs and direct OSU to repay or otherwise remove the sustained questioned costs from its NSF awards.	$169,950	4/30/2023
19-1-017	Oregon State University (9/13/2019)	1.2) Direct OSU to establish a policy to ensure that OSU employees are not paid as both employees and independent contractors.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	1.3) Direct OSU to strengthen its administrative and management procedures over awarding subawards.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	2.1) Resolve the $78,153 in questioned costs.	$78,153	4/30/2023
19-1-017	Oregon State University (9/13/2019)	2.2) Direct OSU to strengthen its administrative and management procedures for obtaining NSF's approval.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	2.3) Direct OSU to strengthen its administrative and management procedures for allocating salary expenses to sponsored projects.	$0	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
19-1-017	Oregon State University (9/13/2019)	2.4) Direct OSU to strengthen its administrative and management procedures for allocating travel expenses to sponsored projects.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	2.5) Direct OSU to strengthen its administrative and management procedures for allocating equipment to sponsored projects.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	2.6) Direct OSU to strengthen its administrative and management procedures over use of PSC funding under NSF awards.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	3.1) Resolve the $65,153 in questioned indirect costs.	$65,153	4/30/2023
19-1-017	Oregon State University (9/13/2019)	3.2) Direct OSU to strengthen its administrative and management procedures for applying indirect costs to Federal awards.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	4.1) Resolve $31,319 in questioned supplies, equipment, and travel costs.	$31,319	4/30/2023
19-1-017	Oregon State University (9/13/2019)	4.2) Direct OSU to strengthen its administrative and management procedures for purchases at end of a project's POP.	$0	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
19-1-017	Oregon State University (9/13/2019)	4.3) Direct OSU to strengthen its administrative and management procedures for travel taken within the final 90 days of an award's POP.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	5.1) Resolve $10,574 in Questioned unallocable costs.	$10,574	4/30/2023
19-1-017	Oregon State University (9/13/2019)	5.2) Direct OSU to strengthen its administrative and management procedures for allocating expenses to sponsored projects.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	5.3) Direct OSU to encourage PIs to identify all award participants.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	6.1) Resolve the $8,820 in questioned costs.	$8,820	4/30/2023
19-1-017	Oregon State University (9/13/2019)	6.2) Direct OSU to strengthen its administrative and management procedures for honorarium payments.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	7.1) Resolve $5,563 in questioned lodging and M&IE costs.	$5,563	4/30/2023
19-1-017	Oregon State University (9/13/2019)	7.2) Direct OSU to strengthen its administrative and management procedures for reimbursing M&IE expenses.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	7.3) Direct OSU to strengthen its administrative and management procedures for reimbursing lodging expenses.	$0	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
19-1-017	Oregon State University (9/13/2019)	8.1) Direct OSU to strengthen its administrative and management procedures for travel, procurement, PSCs, effort certifications, cost transfers, fellowship appointments, and currency conversions.	$0	4/30/2023
19-1-017	Oregon State University (9/13/2019)	9.1) Direct OSU to strengthen its administrative and management procedures for establishing indirect cost rates for Federal awards.	$0	4/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	1.1) Resolve the $136,024 in questioned conference, travel, and AURA service costs and direct UNC to repay or otherwise remove the sustained questioned costs from its NSF awards.	$136,024	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	1.2) Direct UNC to provide support verifying that it has repaid or otherwise credited the $39,389 of questioned equipment, internal service center, salary, and other direct costs for which it has agreed to reimburse NSF.	$39,389	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	1.3) Direct UNC to strengthen its policies and procedures related to the creation and retention of documentation.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	1.4) Direct UNC to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports.	$0	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	1.5) Direct UNC to strengthen its administrative and management processes and procedures surrounding the approval of vendor and service provider invoices.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	1.6) Direct UNC to strengthen its administrative and management processes and procedures surrounding the internal service center billing process.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	1.7) Direct UNC to strengthen its administrative and management processes and procedures surrounding the reconciliation and tracking of gift cards or other prepaid cards.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	2.1) Resolve the $164,313 in questioned subaward costs and direct UNC to repay or otherwise remove the sustained questioned costs from its NSF awards.	$164,313	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	2.2) Direct UNC to strengthen the administrative and management controls and processes over transferring significant parts of federally funded research to other organizations.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	3.1) Direct UNC to provide support verifying that it has repaid or otherwise credited the $103,250 of questioned unsupported ACM$ cash drawdowns for which it has agreed to reimburse NSF.	$103,250	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	3.2) Direct UNC to strengthen the administrative and management controls and processes over its ACM$ reconciliation process.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	4.1) Resolve the $26,505 in inappropriately allocated materials and supplies, travel, and equipment costs for which UNC has not agreed to reimburse NSF and direct UNC to repay or otherwise remove the sustained questioned costs from its NSF awards.	$26,505	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	4.2) Direct UNC to provide support verifying that it has repaid or otherwise credited the $61,496 of questioned materials and supplies, travel, equipment, and other direct costs for which it has agreed to reimburse NSF.	$61,496	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	4.3) Direct UNC to strengthen its administrative and management processes and procedures surrounding the approval of materials and supplies, travel, equipment, and other direct costs charged or transferred to an NSF award near the award's expiration date.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	4.4) Direct UNC to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports.	$0	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	4.5) Direct UNC to strengthen its administrative and management processes and procedures surrounding the allocation of equipment and publication expenses to NSF awards	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	4.6) Direct UNC to strengthen its administrative and management processes and procedures surrounding the allocation of publication expenses.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	5.1) Resolve the $11,542 in meal and lodging per diem expenses for which UNC has not agreed to reimburse NSF and direct UNC to repay or otherwise remove the sustained questioned costs from its NSF awards.	$11,542	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	5.2) Direct UNC to provide support verifying that it has repaid or otherwise credited the $75,065 in questioned pre-award, PSC, airfare, and other direct cost expenses for which it has agreed to reimburse NSF.	$75,065	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	5.3) Direct UNC to strengthen its administrative and management processes and procedures surrounding the review of pre-award travel expenses.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	5.4) Direct UNC to update its meal and lodging per diem policies to comply with Federal regulations.	$0	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	5.5) Direct UNC to strengthen its administrative and management processes and procedures surrounding the use of PSC funding.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	5.6) Direct UNC to strengthen its administrative and management processes and procedures surrounding the approval of airfare expenses.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	5.7) Direct UNC to strengthen its administrative processes surrounding the approval of other direct costs charged to Federal awards.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	6.1) Direct UNC to provide support verifying that it has repaid or otherwise credited the $65,314 of questioned indirect costs for which it has agreed to reimburse NSF.	$65,314	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	6.2) Direct UNC to strengthen its administrative and management procedures for applying indirect costs to Federal awards.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	7.1) Resolve the $30,435 in questioned costs related to inappropriately procured equipment and services for which UNC has not agreed to reimburse NSF and direct UNC to repay or otherwise remove the sustained questioned costs from its NSF awards.	$30,435	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	7.2) Direct UNC to provide support verifying that it has repaid or otherwise credited the $5,143 in server costs for which it has agreed to reimburse NSF.	$5,143	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	7.3) Direct UNC to strengthen its administrative and management procedures related to competitive bidding.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	8.1) Direct UNC to provide support to verify that it has repaid or otherwise credited the $17,136 of questioned costs caused by accounting issues for which it has agreed to reimburse NSF.	$17,136	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	8.2) Direct UNC to strengthen its administrative and management procedures related to handling NSF awards.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	9.1) Direct UNC to provide support to verify that it has repaid or otherwise credited the $9,059 of questioned costs in inappropriately treated GRFP expenses for which it has agreed to reimburse NSF.	$9,059	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	9.2) Direct UNC to update its current practices for award set-up to ensure that personnel working on the award, directly or indirectly, have knowledge of specific NSF terms and conditions that apply to special types of NSF awards.	$0	9/30/2023

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OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	10.1) Direct UNC to strengthen its administrative and management procedures related to the processing and certification of effort.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	11.1) Direct UNC to update its current practices for award set-up to ensure that personnel set up accounts for NSF awards such that the account applies indirect costs at the rates in effect as of the awarding date of the NSF award.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.1) Direct UNC to strengthen the administrative and management policies and procedures in place related to establishing agreements with, and making payments to contractors and consultants	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.2) Direct UNC to strengthen its policies and procedures related to the creation and retention of documentation, including introducing additional controls to help ensure that UNC appropriately creates and maintains all documentation necessary to support	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.3) Direct UNC to strengthen its policies and procedures related to establishing and monitoring subawards.	$0	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.4) Direct UNC to strengthen its policies and procedures related to approving travel expense reports.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.5) Direct UNC to issue clarifying guidance regarding its competitive bidding and sole-source justification requirements.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.6) Direct UNC to strengthen its administrative and management processes and procedures surrounding the internal service center billing process.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.7) Direct UNC to provide periodic training to personnel responsible for capitalizing equipment to ensure items that do not qualify as capital assets are not capitalized.	$0	9/30/2023
20-1-004	University of North Carolina at Chapel Hill (7/13/2020)	12.8) Direct UNC to strengthen its administrative and management processes and procedures surrounding the payment of hourly employees.	$0	9/30/2023
20-1-005	University of Houston (7/23/2020)	1.1) Resolve the $32,153 in questioned unallocable software, tuition remission, stipend, supply, and travel costs for which UH has not agreed to reimburse NSF and direct UH to repay or otherwise remove the sustained questioned costs from its NSF awards.	$32,153	12/15/2023

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OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-005	University of Houston (7/23/2020)	1.2) Direct UH to provide documentation that it has repaid or otherwise credited the $21,513 in questioned conference, travel, and workshop costs for which it has agreed to reimburse NSF.	$21,513	12/15/2023
20-1-005	University of Houston (7/23/2020)	1.3) Direct UH to strengthen its administrative and management controls and processes for allocating expenses to sponsored projects.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	1.4) Direct UH to encourage PIs to identify all award participants and report all award-related travel in the annual reports submitted to NSF.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.1) Resolve the $17,787 in questioned conference, supply, currency conversion, and publication expenses for which UH has not agreed to reimburse NSF and direct UH to repay or otherwise remove the sustained questioned costs from its NSF awards.	$17,787	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.2) Direct UH to provide documentation that it has repaid or otherwise credited the $19,790 in questioned fringe, conference, airfare, parking, and lodging costs for which it has agreed to reimburse NSF.	$19,790	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.3) Direct UH to strengthen its policies and procedures related to the creation and retention of documentation	$0	12/15/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-005	University of Houston (7/23/2020)	2.4) Direct UH to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.5) Direct UH to strengthen its administrative and management procedures surrounding expenses charged to NSF awards after the award has expired.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.6) Direct UH to strengthen its administrative and management procedures surrounding the processing of invoices to ensure that it pays all invoices in a timely manner.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.7) Direct UH to ensure that it only applies fringe benefits based on eligible employee salary costs, as outlined in its Negotiated Indirect Cost Rate Agreement.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.8) Direct UH to establish clear guidance regarding the allowability of publication expenses.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	2.9) Direct UH to establish clear guidance regarding the allowability of participant expenses.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	3.1) Direct UH to provide documentation that it has repaid or otherwise credited the $19,445 in questioned indirect costs for which it has agreed to reimburse NSF.	$0	12/15/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-005	University of Houston (7/23/2020)	3.2) Direct UH to strengthen its administrative and management procedures for applying indirect costs to Federal awards.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	4.1) Resolve the $7,650 in questioned inappropriately procured goods and services for which UH has not agreed to reimburse NSF and direct UH to repay or otherwise remove the sustained questioned costs from its NSF awards.	$7,650	12/15/2023
20-1-005	University of Houston (7/23/2020)	4.2) Direct UH to provide documentation that it has repaid or otherwise credited the $3,306 of questioned costs that it has agreed to reimburse.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	4.3) Direct UH to strengthen its administrative and management controls and processes for procuring goods and services that it will charge to NSF awards.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	5.1) Direct UH to provide documentation that it has repaid or otherwise credited the $9,954 in questioned costs for which it has agreed to reimburse NSF.	$9,954	12/15/2023
20-1-005	University of Houston (7/23/2020)	5.2) Direct UH to strengthen its policies and procedures related to the creation and retention of documentation	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	5.3) Direct UH to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports.	$0	12/15/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-005	University of Houston (7/23/2020)	6.1) Direct UH to provide documentation that it has repaid or otherwise credited the $1,707 of questioned costs for which it has agreed to reimburse NSF.	$1,707	12/15/2023
20-1-005	University of Houston (7/23/2020)	6.2) Direct UH to update its current practices for award set-up to ensure that it appropriately communicates all NSF award terms and conditions.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	7.1) Direct UH to strengthen its administrative and management procedures for approving consultant and independent contractor payments.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	7.2) Direct UH to strengthen its administrative and management procedures for incurring travel costs related to sponsored projects.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	7.3) Direct UH to strengthen its administrative and management procedures surrounding effort reporting.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	7.4) Direct UH to issue specific guidance regarding when UH can pay individuals through participant support stipends.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	7.5) Direct UH to strengthen its administrative and management procedures for equipment expenditures in the final 6 months of a grant's POP to ensure that personnel obtain the Office of Contracts and Grants' approval before purchasing equipment.	$0	12/15/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-005	University of Houston (7/23/2020)	8.1) Direct UH to update its current award set-up practices to ensure that it sets up accounts for NSF awards such that the account applies indirect costs at the rates established in the NICRA that was in effect as of the date of grant award.	$0	12/15/2023
20-1-005	University of Houston (7/23/2020)	9.1) Direct UH to update its current practices for specialized service facilities to ensure that it complies with all of the Federal requirements for these facilities, as outlined in 2 CFR §200.468, Specialized service facilities.	$0	12/15/2023
20-1-007	Yale University (8/11/2020)	1.1) Resolve the $26,151 in salary, promotional, and airfare expenses for which Yale has not agreed to reimburse NSF and direct Yale to repay or otherwise remove the sustained questioned costs from its NSF awards.	$26,151	12/29/2023
20-1-007	Yale University (8/11/2020)	1.2) Direct Yale to provide documentation supporting that it has repaid or otherwise credited the $81,993 in questioned participant support costs, salary, duplicate charges, airfare, travel, and other expenses for which it has agreed to reimburse NSF.	$81,993	12/29/2023
20-1-007	Yale University (8/11/2020)	1.3) Direct Yale to strengthen its administrative and management processes and procedures surrounding the use of participant support cost funding.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	1.4) Direct Yale to strengthen its policies and procedures surrounding the approval of summer effort commitments on sponsored projects.	$0	12/29/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-007	Yale University (8/11/2020)	1.5) Direct Yale to strengthen its administrative and management processes and procedures surrounding the approval of expenses to ensure that it does not approve duplicate expenses submitted by subawardees, vendors, and employees.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	1.6) Direct Yale to implement a control that flags potential duplicate payments for additional review.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	1.7) Direct Yale to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	1.8) Direct Yale to update its travel policies and procedures to include specific guidance regarding how to identify and appropriately account for expenses associated with cancelled or unused airfare.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	1.9) Direct Yale to strengthen its administrative processes surrounding the approval of other direct costs charged to Federal awards.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	1.10) Direct Yale to strengthen its administrative processes surrounding the approval of publication costs charged to Federal awards.	$0	12/29/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-007	Yale University (8/11/2020)	2.1) Resolve the $58,577 in questioned unallocable equipment costs for which Yale has not agreed to reimburse NSF and direct Yale to repay or otherwise remove the sustained questioned costs from its NSF awards.	$58,577	12/29/2023
20-1-007	Yale University (8/11/2020)	2.2) Direct Yale to provide documentation supporting that it has repaid or otherwise credited the $24,732 of questioned materials, publication, travel, and other direct costs for which it has agreed to reimburse NSF.	$24,732	12/29/2023
20-1-007	Yale University (8/11/2020)	2.3) Direct Yale to strengthen its administrative and management processes and procedures surrounding the approval of equipment and materials charged to an NSF award near the award's expiration date.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	2.4) Direct Yale to strengthen its administrative and management processes and procedures surrounding the allocation methodology used to charge equipment, materials/supplies, travel, and other direct costs to sponsored awards.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	2.5) Direct Yale to strengthen its administrative processes surrounding the approval of publication costs charged to Federal awards.	$0	12/29/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-007	Yale University (8/11/2020)	2.6) Direct Yale to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	3.1) Resolve the $39,850 in questioned professional services agreement costs for which Yale has not agreed to reimburse NSF and direct Yale to repay or otherwise remove the sustained questioned costs from its NSF award.	$39,850	12/29/2023
20-1-007	Yale University (8/11/2020)	3.2) Review Yale's re-charging of the questioned cost amounts for compliance with Federal, NSF, and Yale regulations and policies.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	3.3) Direct Yale to strengthen its administrative and management controls and processes surrounding the execution of professional services and consulting agreements.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	4.1) Resolve the $12,855 in questioned internal service provider expenses for which Yale has not agreed to reimburse NSF and direct Yale to repay or otherwise remove the sustained questioned costs from its NSF awards.	$12,855	12/29/2023
20-1-007	Yale University (8/11/2020)	4.2) Direct Yale to provide documentation supporting that it has repaid or otherwise credited the $2,397 in inappropriately billed internal service provider expenses for which it has agreed to reimburse NSF.	$2,397	12/29/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-007	Yale University (8/11/2020)	4.3) Direct Yale to strengthen its administrative and management processes and procedures surrounding internal service provider billings.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	4.4) Direct Yale to strengthen its administrative and management processes and procedures surrounding the development of internal service provider rate sheets.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	4.5) Direct Yale to update its invoicing process for the CINSTR, ISP011, ISP043, ISP058, ISP455, and YRISPS internal service providers to require that invoices identify the number of unit(s) or hour(s) billed, as well as the rate(s) used to calculate the	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	5.1) Direct Yale to provide documentation supporting that it has repaid or otherwise credited the $5,418 of questioned indirect costs for which it has agreed to reimburse NSF.	$5,418	12/29/2023
20-1-007	Yale University (8/11/2020)	5.2) Direct Yale to strengthen its oversight procedures surrounding the charging of, or transferring of, expenses related to rearrangement, alteration, and other capital expenditures.	$0	12/29/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-007	Yale University (8/11/2020)	5.3) Direct Yale to perform periodic reviews of expenditures charged to its facilities accounts to ensure rearrangement and alteration costs are not inappropriately charged to accounts that accumulate modified total direct costs to which Yale applies its	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	6.1) Direct Yale personnel who are independent from the monthly NSF cash draw down process to perform periodic Award Cash Management $service reconciliations	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	7.1) Direct Yale to update its current practices for establishing indirect cost rates to apply to sponsored projects awarded during provisional rate periods	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	8.1) Direct Yale to publish specific guidance regarding how travelers should document travel that includes both personal and business travel.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	8.2) Direct Yale to strengthen its policies and procedures surrounding the creation and retention of documentation	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	8.3) Direct Yale to strengthen its administrative and management procedures related to the effort certification process.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	8.4) Direct Yale to strengthen its administrative and management procedures surrounding the establishment of temporary appointments.	$0	12/29/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
20-1-007	Yale University (8/11/2020)	8.5) Verify that Yale has updated its subaward invoicing payment procedures within the Workday system to ensure that personnel review and approve all subaward invoices within 30 days of receipt	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	8.6) Direct Yale to strengthen its administrative and management procedures surrounding the procurement of consulting services.	$0	12/29/2023
20-1-007	Yale University (8/11/2020)	8.7) Direct Yale to strengthen its administrative and management processes surrounding the payment of invoices submitted by new vendors.	$0	12/29/2023
21-1-004	University of Florida (1/15/2021)	1.1) Resolve the $412,363 in questioned subaward costs.	$412,363	5/31/2023
21-1-004	University of Florida (1/15/2021)	1.2) Direct UF to strengthen the administrative and management internal controls and processes over transferring significant parts of NSF funded research to other organizations.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	2.1) Resolve the $47,226 in questioned participant support, travel, and publication expenses for which UF has not agreed to reimburse NSF.	$47,226	5/31/2023
21-1-004	University of Florida (1/15/2021)	2.2) Direct UF to provide documentation that it has repaid or otherwise credited the $66,590.	$66,590	5/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-004	University of Florida (1/15/2021)	2.3) Direct UF to establish clear guidance regarding the use of participant support cost funding.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	2.4) Direct UF to strengthen its administrative and management procedures and internal controls surrounding the purchase of airfare and the approval of travel expense reports.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	2.5) Direct UF to strengthen its administrative and management procedures and internal controls.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	2.6) Direct UF to establish clear guidance regarding the allowability of publication expenses	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	3.1) Resolve the $83,227 in questioned supplies, software, severance and publication costs.	$83,277	5/31/2023
21-1-004	University of Florida (1/15/2021)	3.2) Direct UF to provide documentation that it has repaid or otherwise credited the $29,600.	$29,600	5/31/2023
21-1-004	University of Florida (1/15/2021)	3.3) Direct UF to strengthen its administrative and management procedures, internal controls, and processes for allocating salary, publication, material and supply, travel, and tuition expenses.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	4.1) Direct UF to provide documentation that it has repaid or otherwise credited the $1,717.	$1,717	5/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-004	University of Florida (1/15/2021)	4.2) Direct UF to update its current procedures and internal controls for reviewing stipend costs charged to Graduate Research Fellowship Program awards.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	5.1) Direct UF to strengthen its directives/procedures and internal controls for procuring goods and services.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	5.2) Direct UF to strengthen its directives/procedures and internal controls surrounding the completion of Cost Accounting Standards exemptions.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	5.3) Direct UF to strengthen its directives/procedures and internal controls for incurring travel costs.	$0	5/31/2023
21-1-004	University of Florida (1/15/2021)	6.1) Direct UF to update its current award set-up practices.	$0	5/31/2023
21-1-007	Clemson University (4/30/2021)	1.1) Resolve the $49,814 in questioned capital expenses for which Clemson has not agreed to reimburse NSF and direct Clemson to repay or otherwise remove the sustained questioned costs from its NSF awards.	$49,814	6/30/2023
21-1-007	Clemson University (4/30/2021)	1.2) Direct Clemson to provide documentation supporting that it has repaid or otherwise credited the $33,434 of questioned capital expenses, subawards, and participant support costs for which it has agreed to reimburse NSF.	$33,434	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-007	Clemson University (4/30/2021)	1.3) Direct Clemson to strengthen its monitoring procedures and internal control processes for applying indirect costs to Federal awards.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	2.1) Resolve the $20,471 in questioned unallocable equipment, travel, other direct cost, and publication expenses for which Clemson has not agreed to reimburse NSF and direct Clemson to repay or otherwise remove the sustained QC from its NSF awards.	$20,471	6/30/2023
21-1-007	Clemson University (4/30/2021)	2.2) Direct Clemson to provide documentation supporting that it has repaid or otherwise credited the $36,847 of questioned equipment, travel, other direct costs, and publication costs for which it has agreed to reimburse NSF.	$36,847	6/30/2023
21-1-007	Clemson University (4/30/2021)	2.3) Direct Clemson to strengthen its administrative and management controls and processes for allocating expenses to sponsored projects.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	2.4) Direct Clemson to encourage Principal Investigators to identify and report all award-related travel in their annual reports to NSF.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	2.5) Direct Clemson to implement a process to ensure that personnel review the reasonableness of all employee, non-employee, and participant travel days and charges at the time of reimbursement.	$0	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-007	Clemson University (4/30/2021)	2.6) Direct Clemson's Office of Grants and Contracts administrative to provide training on how to assess the methodology for allocating publication costs across each sponsored award acknowledged in the publication and document the justification methodology.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	3.1) Resolve the $58,000 in questioned computer cluster node expenses for which Clemson has not agreed to reimburse NSF and direct Clemson to repay or otherwise remove the sustained questioned costs from its NSF awards.	$58,000	6/30/2023
21-1-007	Clemson University (4/30/2021)	3.2) Direct Clemson to periodically assess the fee structure and period allotted for access to the computer cluster node infrastructure.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	3.3) Direct Clemson to strengthen its administrative and management procedures and internal controls for allocating expenses to sponsored projects.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	4.1) Resolve the $4,396 in questioned consultant, participant support, and service center expenses for which Clemson has not agreed to reimburse NSF and direct Clemson to repay or otherwise remove the sustained questioned costs from its NSF awards.	$4,396	6/30/2023
21-1-007	Clemson University (4/30/2021)	4.2) Direct Clemson to provide documentation supporting that it has repaid or otherwise credited the $41,224 of questioned consultant and travel costs for which it has agreed to reimburse NSF.	$41,224	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-007	Clemson University (4/30/2021)	4.3) Direct Clemson to strengthen its policies and procedures related to creating and retaining documentation to help ensure that it appropriately creates and maintains all documentation to support the allowability of expenses charged to sponsored programs	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	5.1) Resolve the $2,151 in questioned travel and salary costs for which Clemson has not agreed to reimburse NSF and direct Clemson to repay or otherwise remove the sustained questioned costs from its NSF awards.	$2,151	6/30/2023
21-1-007	Clemson University (4/30/2021)	5.2) Direct Clemson to provide documentation supporting that it has repaid or otherwise credited the $21,538 of questioned travel and participant support costs for which it has agreed to reimburse NSF.	$21,538	6/30/2023
21-1-007	Clemson University (4/30/2021)	5.3) Direct Clemson to strengthen its policies and procedures related to creating and retaining documentation.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	5.4) Direct Clemson to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	5.5) Direct Clemson to establish clear guidance regarding the allowability of participant support funding for employee travel.	$0	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-007	Clemson University (4/30/2021)	5.6) Direct Clemson to establish procedures to ensure that its salary payments do not exceed the employee's Institutional Base Salary.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	6.1) Direct Clemson to provide documentation supporting that it has repaid or otherwise credited the $8,565 of questioned indirect costs for which it has agreed to reimburse NSF.	$8,565	6/30/2023
21-1-007	Clemson University (4/30/2021)	6.2) Direct Clemson to update its current proposal submission and award set-up practices to require that for NSF awards, personnel ensure that the accounts apply indirect costs as directed by the supplemental funding letter	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	7.1) Direct Clemson to ensure that it has performed risk evaluations for all subawards issued prior to June 2018 and that these risk evaluations remain active, to validate the agreements in accordance with Federal regulations.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	8.1) Direct Clemson to update its current pre-award procedures and internal controls for reviewing NSF proposal budgets to ensure that all costs included within the participant support cost budget comply with NSF terms and conditions.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	8.2) Direct Clemson to update its current procedures and internal controls to ensure that Principal Investigators submit final reports to NSF in accordance with NSF's terms and conditions.	$0	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-007	Clemson University (4/30/2021)	9.1) Direct Clemson to strengthen its administrative & mgt procedures for equipment expenditures to ensure that the Office of GCA approves all equipment purchased with non-sponsored funds and subsequently transferred to sponsored funds.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	9.2) Direct Clemson to strengthen its administrative and management procedures to confirm it has completed the subrecipient documentation package before approving non-budgeted subawards.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	9.3) Direct Clemson to strengthen its administrative and management procedures and internal controls related to the effort certification process.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	9.4) Direct Clemson to strengthen its administrative and management processes surrounding document retention for purchases on sponsored awards.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	9.5) Direct Clemson to strengthen its directives, procedures, and internal controls for obtaining approval for foreign travel before the trip occurs.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	9.6) Direct Clemson to strengthen its directives, procedures, and internal controls for procuring contract services on sponsored projects.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	9.7) Direct Clemson to strengthen its procedures and internal controls for reviewing account codes that are required to incur indirect costs.	$0	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-007	Clemson University (4/30/2021)	10.1) Direct Clemson to update its current award set-up practices to require that personnel ensure that the accounts apply indirect costs using the rates that were established in the NICRA in effect as of the date of the NSF grant award.	$0	6/30/2023
21-1-007	Clemson University (4/30/2021)	10.2) Direct Clemson to require subawardees to apply indirect costs using the rates that were established in the NICRA in effect as of the date the subaward was granted, rather than using the rates included within the subaward budget and proposal.	$0	6/30/2023
21-1-008	Emory University (5/13/2021)	1.1) Resolve the $54,419 of unreasonable equipment costs	$54,419	4/30/2023
21-1-008	Emory University (5/13/2021)	1.2) Direct Emory to strengthen its administrative and management procedures to ensure its proposals accurately reflect anticipated costs.	$0	4/30/2023
21-1-008	Emory University (5/13/2021)	2.1) Resolve the $21,057 of unallowable expenses	$21,057	4/30/2023
21-1-008	Emory University (5/13/2021)	2.2) Direct Emory to strengthen its administrative and management procedures	$0	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-008	Emory University (5/13/2021)	3.1) Resolve the $11,298 of unallowable indirect costs	$11,298	4/30/2023
21-1-008	Emory University (5/13/2021)	3.2) Direct Emory to strengthen its administrative and management procedures for equipment purchases and participant support costs.	$0	4/30/2023
21-1-008	Emory University (5/13/2021)	4.1) Resolve the $3,110 of unsupported supplemental pay,	$3,110	4/30/2023
21-1-008	Emory University (5/13/2021)	4.2) Direct Emory to strengthen its administrative and management procedures to ensure Emory personnel adequately support supplemental pay requests.	$0	4/30/2023
21-1-011	Florida International University (5/19/2021)	1.1) Resolve the $1,252 in questioned Award Cash Management $ervice drawdowns	$1,252	4/30/2023
21-1-011	Florida International University (5/19/2021)	1.2) Direct FIU to provide documentation supporting that it has repaid or otherwise credited the $14,167 of questioned costs	$14,167	4/30/2023
21-1-011	Florida International University (5/19/2021)	1.3) Direct FIU to update its administrative and management processes and internal control procedures surrounding the ACM$ for awards with expiring appropriations	$0	4/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-011	Florida International University (5/19/2021)	1.4) Direct FIU to strengthen its award set-up processes and procedures	$0	4/30/2023
21-1-011	Florida International University (5/19/2021)	2.1) Resolve the $791 in questioned fringe benefit costs for which FIU has not agreed to reimburse NSF	$791	4/30/2023
21-1-011	Florida International University (5/19/2021)	2.2) Direct FIU to provide documentation supporting that it has repaid or otherwise credited the $5,934 of questioned promotional and salary costs	$5,934	4/30/2023
21-1-011	Florida International University (5/19/2021)	2.3) Direct FIU to establish clear guidance regarding the allowable uses of participant support cost funding	$0	4/30/2023
21-1-011	Florida International University (5/19/2021)	2.4) Direct FIU to strengthen its monitoring procedures surrounding costs charged to its NSF Research Experiences for Undergraduates programs	$0	4/30/2023
21-1-011	Florida International University (5/19/2021)	3.1) Direct FIU to update its current practices to ensure it only applies approved fringe benefits	$0	4/30/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	1.1) Resolve the $16,351 in questioned salary expenses for which Caltech has not agreed to reimburse NSF and direct Caltech to repay or otherwise remove the sustained questioned costs from its NSF awards.	$16,351	1/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	1.2) Direct Caltech to provide documentation supporting that it has repaid or otherwise credited the $418 of questioned salary expenses for which it has agreed to reimburse NSF.	$418	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	1.3) Direct Caltech to strengthen its policies and procedures by retroactively establishing expiration dates on its use of the Other Paid Leave Pool on federal awards and ensuring that these expiration dates align with Flexibility 6 of OMB Memo M-20-17	$0	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	2.1) Resolve the $31,856 in questioned subaward expenses for which Caltech has not agreed to reimburse NSF and direct Caltech to repay or otherwise remove the sustained questioned costs from its NSF awards.	$31,856	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	2.2) Direct Caltech to strengthen its internal control processes and procedures surrounding the transfer of significant portions of NSF-funded research to other organizations.	$0	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	3.1) Direct Caltech to provide documentation supporting that it has repaid or otherwise credited the $1,515 of questioned indirect costs for which it has agreed to reimburse NSF.	$1,515	1/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	3.2) Direct Caltech to strengthen its monitoring procedures and internal control processes for applying indirect costs to Federal awards.	$0	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	3.3) Direct Caltech to quantify the total indirect costs inappropriately applied to NSF awards as a result of its rental equipment account inappropriately applying indirect costs and to reimburse NSF for the appropriate amount.	$0	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	4.1) Direct Caltech to provide documentation supporting that it has repaid or otherwise credited the $581 of questioned salary and fringe costs for which it has agreed to reimburse NSF.	$581	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	4.2) Direct Caltech to strengthen its administrative and management controls and processes surrounding the charging of salary to Intergovernmental Personnel Act awards.	$0	1/31/2023
21-1-014	California Institute of Technology (Caltech) (5/26/2021)	5.1) Direct Caltech to update its current award set-up practices to require that, when setting up accounts established for NSF awards, personnel ensure that the accounts apply indirect costs using either the rates that were established in the NICRA.	$0	1/31/2023
21-1-017	Tennessee State University (7/20/2021)	1.1) Resolve the $99,811 in questioned unsupported stipend and payroll costs, and direct TSU to repay or otherwise remove the sustained questioned costs from its NSF awards.	$99,811	7/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-017	Tennessee State University (7/20/2021)	1.2) Direct TSU to provide documentation supporting that it has repaid or otherwise credited the $21,986 in questioned unsupported stipend and payroll costs, for which it has agreed to reimburse NSF.	$21,986	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	1.3) Direct TSU to strengthen the administrative and management controls and processes over obtaining and maintaining sufficient supporting documentation.	$0	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	2.1) Resolve the $11,371 in inappropriately allocated equipment costs, and direct TSU to repay or otherwise remove the sustained questioned costs from its NSF awards.	$11,371	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	2.2) Direct TSU to provide documentation supporting that it has repaid or otherwise credited the $5,514 in questioned payroll and general ledger costs, for which it has agreed to reimburse NSF.	$5,514	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	2.3) Direct TSU to strengthen its administrative and management controls and processes over the proper allocation of costs.	$0	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	3.1) Resolve the $15,391 in questioned participant support costs and direct TSU to repay or otherwise remove the sustained questioned costs from its NSF awards.	$15,391	7/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-017	Tennessee State University (7/20/2021)	3.2) Direct TSU to provide documentation supporting that it has repaid or otherwise credited the $420 in indirect costs, for which it has agreed to reimburse NSF.	$420	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	3.3) Direct TSU to update its administrative and management processes and internal control procedures related to assigning participant support costs within its accounting system.	$0	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	4.1) Direct TSU to provide documentation supporting that it has repaid or otherwise credited the $939 in questioned unsupported Award Cash Management $ervice (ACM$) drawdowns, for which it has agreed to reimburse NSF.	$939	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	4.2) Direct TSU to update its administrative and management processes and internal control procedures surrounding the ACM$ system.	$0	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	5.1) Direct TSU to strengthen the administrative and management procedures over certifying time and effort reports in a timely manner.	$0	7/31/2023
21-1-017	Tennessee State University (7/20/2021)	5.2) Direct TSU to strengthen the administrative and management procedures to require the inclusion of pertinent information on time and effort reports such as fund codes, award numbers, and work descriptions.	$0	7/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-019	University of Pittsburgh (8/30/2021)	1.1) Direct Pitt to provide documentation supporting that it has repaid or otherwise credited the $42,450 of questioned unsupported materials & supplies, salary, & travel costs for which it has agreed to reimburse NSF.	$42,450	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	1.2) Direct Pitt to strengthen the administrative and management controls, training, processes, and procedures related to maintaining a proper audit trail.	$0	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	2.1) Resolve the $8,616 of questioned equipment and material & supply costs for which Pitt has not agreed to reimburse NSF and direct Pitt to repay or otherwise remove the sustained questioned costs from its NSF awards.	$8,616	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	2.2) Direct Pitt to provide documentation supporting that it has repaid or otherwise credited the $26,357 of questioned equipment and material & supply costs for which it has agreed to reimburse NSF.	$26,357	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	2.3) Direct Pitt to strengthen the administrative and management controls, training, processes, and procedures over expenditures near the end of an award.	$0	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	3.1) Resolve the $4,584 of questioned unallocable and unreasonable equipment costs for which Pitt has not agreed to reimburse NSF and direct Pitt to repay or otherwise remove the sustained questioned costs from its NSF awards.	$4,584	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-019	University of Pittsburgh (8/30/2021)	3.2) Direct Pitt to provide documentation supporting that it has repaid or otherwise credited the $23,391 of questioned unallocable and unreasonable conference catering, equipment, & travel costs for which it has agreed to reimburse NSF.	$23,391	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	3.3) Direct Pitt to strengthen the administrative and management controls, training, processes, and review procedures for the NSF award expenditures.	$0	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	4.1) Direct Pitt to provide documentation supporting that it has repaid or otherwise credited the $869 of questioned overcharged indirect costs for which it has agreed to reimburse NSF.	$869	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	4.2) Direct Pitt to develop and implement controls to identify situations when indirect cost rates change between proposal submission and award date and to take appropriate steps to avoid claiming unallowable indirect costs on NSF awards.	$0	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	5.1) Direct Pitt to provide documentation supporting that it has repaid or otherwise credited the $392 of questioned participant support costs for which it has agreed to reimburse NSF.	$392	6/30/2023
21-1-019	University of Pittsburgh (8/30/2021)	5.2) Direct Pitt to strengthen the administrative and management procedures over allocating participant support costs to sponsored projects.	$0	6/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-020	University of California, San Francisco (9/29/2021)	1.1) Resolve the $55,739 in questioned, unallocable publication and other direct costs for which UCSF has not agreed to reimburse NSF	$55,739	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	1.2) Direct UCSF to provide documentation supporting that it has repaid or otherwise credited the $20,253 in questioned, unallocable publication and other direct costs	$20,253	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	1.3) Direct UCSF to strengthen its administrative and management controls and processes for supporting the allocation of expenses to sponsored projects	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	2.1) Resolve the $21,324 in questioned participant support and travel costs for which UCSF has not agreed to reimburse NSF	$21,324	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	2.2) Direct UCSF to provide documentation supporting that it has repaid or otherwise credited the $15,375 of questioned participant support, travel and salary costs	$15,375	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	2.3) Direct UCSF to establish clear guidance regarding the allowable uses of participant support cost funding	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	2.4) Direct UCSF to strengthen its administrative and management processes to ensure credits received from vendors are appropriately reimbursed to the original funding source(s) charged	$0	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-020	University of California, San Francisco (9/29/2021)	2.5) Direct UCSF to strengthen its administrative and management processes and procedures surrounding the approval of travel expense reports	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	2.6) Direct UCSF to provide training regarding the policy requirements for salary charged to NSF awards to ensure payroll is processed timely	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	3.1) Resolve the $14,365 in questioned, inadequately supported subaward and animal care expenses	$14,365	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	3.2) Direct UCSF to strengthen its policies and procedures related to creating and retaining documentation, including introducing additional controls to help ensure it appropriately creates and maintains all documentation	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	4.1) Resolve the $8,402 in questioned indirect costs for which UCSF has not agreed to reimburse NSF	$8,402	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	4.2) Direct UCSF to provide documentation supporting that it has repaid or otherwise credited the $1,352 of questioned indirect costs	$1,352	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	4.3) Direct UCSF to strengthen its monitoring procedures and internal control processes for applying indirect costs to federal awards	$0	9/30/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
21-1-020	University of California, San Francisco (9/29/2021)	5.1) Direct UCSF to strengthen its administrative and management procedures for rentals to ensure employees use Connexxus to rent vehicles	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	5.2) Direct UCSF to strengthen its administrative and management procedures related to subaward processing	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	5.3) Direct UCSF to strengthen its directives, procedures, and internal controls for procuring contract services on sponsored projects	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	5.4) Direct UCSF to strengthen its procedures and internal controls for reviewing expense(s) eligibility for inclusion or exclusion from the Modified Total Direct Cost base	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	6.1) Direct UCSF to develop and implement a control to identify when indirect cost rates change between provisional rates and newly negotiated indirect cost rates	$0	9/30/2023
21-1-020	University of California, San Francisco (9/29/2021)	6.2) Direct UCSF to develop and implement a control to identify when indirect cost rates change between proposal submission and award date	$0	9/30/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	1.1) Resolve the $268,340 in questioned and non-compliant cost share expenditures and direct URI to remove the sustained questioned and non-compliant cost share expenditures from the cost sharing reports it submitted to NSF	$268,340	8/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	1.2) Direct URI to strengthen its cost sharing monitoring processes to ensure that it appropriately monitors cost share expenditures incurred by Third Party institutions and verifies that the research the institutions are performing is appropriate.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	1.3) Direct URI to strengthen its cost sharing monitoring procedures to ensure institutions responsible for reporting cost share expenditures maintain, and provide URI with, documentation to support that all costs reported to URI are allowable & allocable	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	1.4) Direct URI to strengthen its administrative and management processes related to reporting cost sharing to NSF to ensure that it does not include the same cost share expenditures on multiple cost sharing report	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	2.1) Resolve the $204,383 in questioned subaward costs for which URI has not agreed to reimburse NSF and direct URI to repay or otherwise remove the sustained questioned costs from its NSF awards.	$204,383	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	2.2) Direct URI to provide documentation supporting that it has repaid or otherwise credited the $2,260 of questioned furniture and travel costs for which it has agreed to reimburse NSF.	$2,260	8/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	2.3) Direct URI to strengthen the administrative and management internal controls and processes over transferring significant parts of NSF-funded research to other organizations.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	2.4) Direct URI to strengthen its administrative and management processes to ensure that general-purpose costs charged to federal awards are necessary to carry out grant objectives and are directly related to the purpose of the federal award	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	2.5) Direct URI to strengthen its subaward monitoring process to ensure that its subawardees only claim allowable travel costs.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	3.1) Resolve the $121,719 in questioned indirect and subaward costs for which URI has not agreed to reimburse NSF and direct URI to repay or otherwise remove the sustained questioned costs from its NSF awards.	$121,719	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	3.2) Direct URI to strengthen its monitoring procedures and internal control processes for applying indirect costs to federal awards. Updated procedures could include conducting annual training regarding when materials used in the fabrication of an asset	$0	8/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	3.3) Direct URI to strengthen its subaward monitoring procedures to ensure that subawardees only apply indirect costs to expenses that should be included in their Modified Total Direct Cost base.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	4.1) Resolve the $24,683 in questioned inadequately supported subaward expenses for which URI has not agreed to reimburse NSF and direct URI to repay or otherwise remove the sustained questioned costs from its NSF awards.	$24,683	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	4.2) Direct URI to strengthen its subaward monitoring procedures to ensure subawardees create and maintain documentation to support that all costs invoiced to URI are reasonable, allowable, and allocable.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	5.1) Direct URI to provide documentation supporting that it has repaid or otherwise credited the $6,363 in questioned unallocable equipment costs for which URI has agreed to reimburse NSF.	$6,363	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	5.2) Direct URI to strengthen its administrative and management controls and processes for supporting the allocation of expenses to sponsored projects.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	6.1) Direct URI to strengthen its administrative and management procedures related to the issuance and monitoring of subawards to ensure that personnel complete all required forms per URI's policies.	$0	8/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	6.2) Direct URI to strengthen its directives, procedures, and internal controls for procuring equipment on sponsored projects.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	6.3) Direct URI to strengthen its internal controls for reviewing re-certified salary expense(s) to ensure the Controller's Office appropriately approves all re-certified salary before URI charges the salary costs to federal awards.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	7.1) Direct URI to update its current practices for establishing indirect cost rates for sponsored projects awarded during provisional rate periods.	$0	8/31/2023
22-1-001	Univ of Rhode Island (EPSCoR) (10/15/2021)	7.2) Direct URI to strengthen its subaward monitoring procedures to ensure subawardees consistently apply indirect costs proposed & claimed on subaward agreements using the negotiated indirect cost rate(s) in effect when the subawards were awarded.	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	1.1) Resolve the $91,220 in questioned inadequately supported subaward expenses, internal service provider rates, and meal expenses	$91,220	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	1.2) Direct UTD to provide documentation that it has repaid or otherwise credited the $551 of questioned travel costs	$0	8/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
22-1-002	University of Texas Dallas (12/9/2021)	1.3) Direct UTD to strengthen its policies and procedures for creating and retaining documentation, including introducing additional controls to help ensure that it appropriately creates and maintains all documentation necessary to support the allowable	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	2.1) Resolve the $65,226 in questioned materials and supplies and travel costs	$65,226	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	2.2) Direct UTD to provide documentation supporting that it has repaid or otherwise credited the $5,378 of questioned airfare, participant, repair, and travel costs	$5,378	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	2.3) Direct UTD to strengthen its controls and processes for supporting the allocation of expenses to sponsored projects	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	2.4) Direct UTD to strengthen its controls and processes for ensuring it allocates travel and other direct cost expenses	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	3.1) Resolve the $63,753 in questioned subaward expenses	$63,753	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	3.2) Direct UTD to strengthen the administrative and management internal controls and procedures over transferring significant parts of NSF-funded research to other organizations	$0	8/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
22-1-002	University of Texas Dallas (12/9/2021)	4.1) Direct UTD to provide documentation supporting that it has repaid or otherwise credited the $23,082 in questioned fringe benefit, travel, indirect costs, and Cost of Education allowance costs	$23,082	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	4.2) Direct UTD to strengthen its processes and procedures surrounding the booking and approval of travel expenses	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	4.3) Direct UTD to establish controls surrounding its participant support costs to ensure it appropriately charges travel for participants to accounts that are not included in its modified total direct cost base	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	4.4) Direct UTD to strengthen its procedures and internal controls surrounding the application of fringe benefits on employee salary	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	4.5) Direct UTD to strengthen its procedures and internal controls surrounding the administrative of Graduate Research Fellowship Program Cost of Education funding	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	5.1) Direct UTD to strengthen its administrative and management procedures for subaward expenses	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	5.2) Direct UTD to strengthen its administrative and management procedures for subrecipients	$0	8/31/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Questioned	Anticipated Resolution Date
22-1-002	University of Texas Dallas (12/9/2021)	5.3) Direct UTD to strengthen its administrative and management procedures surrounding consultant services	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	5.4) Direct UTD to strengthen its administrative and management procedures for travel	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	5.5) Direct UTD to strengthen its administrative and management procedures for equipment	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	5.6) Direct UTD to strengthen its administrative and management procedures for cost transfers	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	5.7) Direct UTD to strengthen its administrative and management procedures to ensure employees certify effort within 45 days	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	5.8) Direct UTD to strengthen its administrative and management procedures for applying indirect cost rates on subrecipient expenses	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	6.1) Direct UTD to update its current practices for applying indirect costs to Innovation Corps awards	$0	8/31/2023
22-1-002	University of Texas Dallas (12/9/2021)	6.2) Direct UTD to update its current practices for monitoring NSF award subrecipients	$0	8/31/2023

Open OIG Recommendations – External Audits (Resolved, Open as of February 1, 2023)

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-001	University of Colorado Boulder (1/10/2020)	1.1) Resolve the $25,902 of questioned material, supply. and, equipment expenditures;	$ 16,698	$ 8,904	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	1.2) Direct CU Boulder to provide support that it has repaid the $7,621 of questioned equipment costs.	$ 4,998	$ 2,623	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	1.3) Direct CU Boulder to strengthen the administrative and management procedures over expenditures near the end of an award	$0	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	2.1) Resolve the $20,575 of questioned publication costs	$ 20,575	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	2.2) Direct CU Boulder to provide support that it has repaid the $78 of questioned material and supplies costs.	$0	$ 78	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	2.3) Direct CU Boulder to strengthen the administrative and management controls and processes over applying the appropriate criteria to Fed and NSF award expenditures.	$0	$0	11/1/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-001	University of Colorado Boulder (1/10/2020)	2.4) Direct CU Boulder to strengthen the administrative and management controls and processes over expenditures charged to awards after the award expiration.	$0	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	3.1) Direct CU Boulder to provide support that it has repaid the $15,785 of questioned travel costs.	$15,785	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	3.2) Direct CU Boulder to strengthen the administrative and management procedures over travel expenditures charged to NSF awards.	$0	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	4.1) Direct CU Boulder to provide support that it has repaid the $4,597 of questioned participant support costs.	$4,597	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	4.2) Direct CU Boulder to strengthen the administrative and management procedures over allocating participant support costs to sponsored projects.	$0	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	5.1) Direct CU Boulder to provide support that it has repaid the $2,728 of questioned salary and wages costs.	$2,728	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	5.2) Direct CU Boulder to strengthen the administrative and management procedures over employee terminations.	$0	$0	11/1/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-001	University of Colorado Boulder (1/10/2020)	6.1) Direct CU Boulder to provide support that it has repaid the $2,545 of questioned costs that did not have adequate documentation to support the expenses charged	$2,545	$0	11/1/2022
20-1-001	University of Colorado Boulder (1/10/2020)	6.2) Direct CU Boulder to strengthen the administrative and management controls, training, processes, and procedures related to document retention.	$0	$0	11/1/2022
20-1-008	Duke University (8/31/2020)	1.1) Resolve the $164,022 in questioned administrative salary and airfare expenses for which Duke has not agreed to reimburse NSF and direct Duke to repay or otherwise remove the sustained questioned costs from its NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.2) Direct Duke to provide documentation to support that it has repaid or otherwise credited the $106,386 of questioned airfare, entertainment, participant support costs, visiting scholar, & other expenses for which it has agreed to reimburse NSF.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.3) Direct Duke to strengthen its policies and procedures related to charging project coordinator time directly to NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.4) Direct Duke to strengthen its policies and procedures related to purchasing airfare that will be charged to a Federal project.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.5) Direct Duke to strengthen its controls surrounding spending on NSF awards for which the sponsor has denied no-cost extension requests.	TBD	TBD	8/8/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-008	Duke University (8/31/2020)	1.6) Direct Duke to strengthen its conference hosting policies and procedures to ensure that it does not charge Federal awards for unallowable entertainment expenses.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.7) Direct Duke to strengthen its administrative and management processes and procedures related to the use of, and the re-budgeting of, participant support cost funding.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.8) Direct Duke to strengthen its policies and procedures related to providing salary and stipend payments to visiting scholars.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.9) Direct Duke to perform periodic reviews of costs accumulated within its general ledger to identify and remove any duplicate expenses charged against Federal awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.10) Direct Duke to strengthen its policies and procedures related to approving travel expense reports.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	1.11) Direct Duke to establish additional controls to help ensure that it appropriately creates and retains all documentation necessary to support the allowability of expenses charged to sponsored programs.	TBD	TBD	8/8/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-008	Duke University (8/31/2020)	1.12)Direct Duke to implement a control to flag any charges against an NSF award when the purchaser incurs the expense more than 90 days before the effective date of an award.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	2.1) Resolve the $237,141 in questioned Office of Information Technology, participant support, and travel expenses for which Duke has not agreed to reimburse NSF.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	2.2) Direct Duke to provide documentation to support that it has repaid or otherwise credited the $9,494 in questioned participant support, travel, and other direct costs for which it has agreed to reimburse NSF.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	2.3) Direct Duke to strengthen its policies and procedures related to creating and retaining documentation.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	2.4) Direct Duke to strengthen its policies and procedures related to internal specialized service center billings.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	2.5) Direct Duke to strengthen its policies and procedures related to participant support cost payments.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	2.6) Direct Duke to strengthen its policies and procedures surrounding participation incentive payments.	TBD	TBD	8/8/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-008	Duke University (8/31/2020)	2.7) Direct Duke to issue guidance regarding how to appropriately document the allowability of medical expense reimbursements for individuals performing fieldwork on Duke's behalf.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	2.8) Direct Duke to strengthen its administrative and management processes and procedures surrounding the approval of travel expenses.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	3.1) Resolve the $77,923 in questioned salary expenses for which Duke has not agreed to reimburse NSF and direct Duke to repay or otherwise remove the sustained questioned costs from its NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	3.2) Direct Duke to strengthen its administrative and management processes and procedures related to establishing supplemental pay appointments.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	3.3) Direct Duke to strengthen its administrative and management processes and procedures related to rehiring former employees as adjunct faculty.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	4.1) Resolve the $29,892 in questioned Award Cash Management $service drawdowns for which Duke has not agreed to reimburse NSF and direct Duke to repay or otherwise remove the sustained questioned costs from its NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	4.2) Direct Duke to strengthen its administrative and management processes and procedures surrounding the drawing-down of funding from the Award Cash Management $service system on awards with expiring appropriations.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	4.3) Direct Duke to strengthen its award set-up processes and procedures to ensure it cannot charge costs to active awards if the Federal appropriations have expired.	TBD	TBD	8/8/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-008	Duke University (8/31/2020)	5.1) Resolve the $9,137 in questioned unallocable chemical analysis costs for which Duke has not agreed to reimburse NSF and direct Duke to repay or otherwise remove the sustained questioned costs from its NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	5.2) Direct Duke to provide documentation to support that it has repaid or otherwise credited the $19,582 in questioned unallocable travel, publication, supply, and participant support expenses for which it has agreed to reimburse NSF.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	5.3) Direct Duke to strengthen its administrative and management controls and processes related to allocating expenses to sponsored projects.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	5.4) Direct Duke to encourage Principal Investigators to identify all award participants and report all award-related travel in the annual reports submitted to NSF.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	6.1) Resolve the $23,406 in questioned costs incurred for inappropriately procured supplies and services for which Duke has not agreed to reimburse NSF and direct Duke to repay or otherwise remove the sustained questioned costs from its NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	6.2) Direct Duke to strengthen its administrative and management procedures related to procuring consultant services.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	6.3) Direct Duke to strengthen its administrative and management procedures related to performing competitive bidding activities.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	7.1) Resolve the $1,672 in questioned Organization for Tropical Studies costs for which Duke has not agreed to reimburse NSF and direct Duke to repay or otherwise remove the sustained questioned costs from its NSF awards.	TBD	TBD	8/8/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-008	Duke University (8/31/2020)	7.2) Direct Duke to provide documentation to support that it has repaid or otherwise credited the $10,854 of questioned Organization for Tropical Studies expenses for which it has agreed to reimburse NSF.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	7.3) Direct Duke to strengthen its administrative and management processes and procedures related to creating contractual relationships with organizations for which it will serve as a legal or fiscal agent.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	8.1) Resolve the $10,000 in questioned non-compliant Graduate Research Internship Program costs for which Duke has not agreed to reimburse NSF and direct Duke to repay or otherwise remove the sustained questioned costs from its NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	8.2) Direct Duke to strengthen its controls related to award set-up to ensure that personnel working on the award, either directly or indirectly, are aware of the specific NSF terms and conditions that apply to special types of NSF awards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	9.1) Direct Duke to provide documentation to support that it has repaid or otherwise credited the $9,397 of questioned indirect costs.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	9.2) Direct Duke to strengthen its administrative and management procedures related accounting for participant support costs.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	10.1) Direct Duke to strengthen its controls related to award set-up.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	11.1) Direct Duke to strengthen its administrative and management procedures related to procuring consultant services.	TBD	TBD	8/8/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
20-1-008	Duke University (8/31/2020)	11.2) Direct Duke to strengthen its policies and procedures related to its subaward payment approval process.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	11.3) Direct Duke to strengthen its procedures for approving cost transfers that involve equipment purchases.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	11.4) Direct Duke to update its current effort reporting processes to ensure that personnel certify their effort in compliance with Duke's internal policies.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	11.5) Direct Duke to strengthen its administrative and management procedures related to its competitive bidding process.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	11.6) Direct Duke to strengthen its policies and procedures surrounding corporate purchase cards.	TBD	TBD	8/8/2022
20-1-008	Duke University (8/31/2020)	11.7) Direct Duke to strengthen its administrative and management procedures related to internal service provider billings.	TBD	TBD	8/8/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	1.1) Resolve the $625,532 in subrecipient indirect costs retained by KUCR and direct KUCR to repay or otherwise remove the sustained questioned costs from its NSF awards	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	1.2) Confirm that KUCR has ended the practice of retaining a portion of allowable subrecipient indirect costs charged to EPSCoR awards.	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	2.1) Resolve the $15,854 in indirect costs charged, and direct KUCR to repay or otherwise remove the sustained questioned costs from its NSF award.	TBD	TBD	9/30/2022

GAO-IG Act Exhibits

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	3.1) Resolve the $569,477 in questioned unsupported subaward costs	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	3.2) Direct KUCR to provide oversight that Haskell is charging actual costs and develops processes to appropriately account for salary and fringe benefit charges	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	3.3) Direct KUCR to strengthen its administrative and management controls and processes related to subaward risk assessment and oversight.	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	3.4) Direct KUCR to strengthen its administrative and management controls and processes related to record retention.	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	4.1) Resolve the $328,494 in questioned cost share costs	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	5.1) Resolve the $10,697 in questioned costs	TBD	TBD	9/30/2022
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	5.2) Direct KUCR to provide training on Federal requirements prohibiting alcoholic beverages and requiring expenses to be necessary and reasonable	TBD	TBD	9/30/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-001	Univ of Kansas Ctr for Research (EPSCoR) (1/7/2021)	5.3) Direct KUCR to strengthen its administrative and management controls and processes related to participant support costs	TBD	TBD	9/30/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	1.1) Resolve the $90,000 in questioned cost share	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	1.2) Direct UW to strengthen its administrative and management controls and processes related to cost transfers	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	2.1) Resolve the $7,908 in questioned commercial printing costs	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	2.2) Direct UW to strengthen its administrative and management controls and processes related to cost transfers.	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	3.1) Resolve the $15,207 in questioned entertainment costs	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	3.2) Direct UW to provide NSF additional detail for proposed SRAP entertainment activities annually so NSF can assess the allowability of the proposed activities.	TBD	TBD	3/31/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	3.3) Direct UW to strengthen its administrative and management controls and processes related to documenting SRAP activity attendees and programmatic purposes.	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	4.1) Resolve the $24,773 in questioned indirect costs	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	4.2) Direct UW to strengthen its policies and controls over identification of participant support costs.	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	5.1) Resolve the $864 in questioned meal costs	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	5.2) Direct UW to develop policy and training on the allowability and reasonableness of meal costs.	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	6.1) Resolve the $117,599 in questioned costs	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	6.2) Direct UW to augment its policy on subrecipient monitoring and develop training to ensure that subrecipients comply with requirements for award management.	TBD	TBD	3/31/2022
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	6.3) Direct UW to not provide future funding to WRNAC until UW confirms WRNAC has the controls to ensure compliance with Federal regulations and NSF award terms and conditions.	TBD	TBD	3/31/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-003	University of Wyoming (EPSCoR) (1/13/2021)	6.4) Direct UW to work with WRNAC to ensure adequate controls are in place to ensure that the risk of conflicts of interest are mitigated and unmanageable conflicts are reported	TBD	TBD	3/31/2022
21-1-009	University of New Mexico (5/13/2021)	1.1) Resolve the $17,269 in questioned unreasonable per diem, airfare, and ground transportation costs for which UNM has not agreed to reimburse NSF and direct UNM to repay or otherwise remove the sustained questioned costs from its NSF awards.	$0	$17,269	9/30/2022
21-1-009	University of New Mexico (5/13/2021)	1.2) Direct UNM to strengthen its administrative and management procedures for reviewing travel expenses incurred on sponsored projects.	$0	$0	9/30/2022
21-1-009	University of New Mexico (5/13/2021)	1.3) Direct UNM to strengthen its policies and procedures regarding the reasonableness of per diem expenses incurred when employees are temporarily relocated for a period longer than 30 days.	$0	$0	9/30/2022
21-1-009	University of New Mexico (5/13/2021)	2.1) Resolve the $3,613 in questioned tuition costs for which UNM has not agreed to reimburse NSF and direct UNM to repay or otherwise remove the sustained questioned costs from its NSF awards.	$3,681	$15	9/30/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-009	University of New Mexico (5/13/2021)	2.2) Direct UNM to provide documentation supporting that it has repaid or otherwise credited the $83 of questioned travel costs for which it has agreed to reimburse NSF.	$83	$0	9/30/2022
21-1-009	University of New Mexico (5/13/2021)	2.3) Direct UNM to strengthen its controls surrounding the approval of expense reimbursements to ensure approvers appropriately verify that travelers are reimbursed at the appropriate U.S. General Services Administration per diem rate(s).	$0	$0	9/30/2022
21-1-009	University of New Mexico (5/13/2021)	2.4) Direct UNM to strengthen its policies and procedures surrounding the use of participant support cost funding to cover tuition remission expenses.	$0	$0	9/30/2022
21-1-009	University of New Mexico (5/13/2021)	3.1) Direct UNM to update its award set-up practices to require that, when setting up accounts established for NSF awards, personnel ensure that the accounts apply indirect costs using the rates that were established in the Negotiated Indirect Cost Rate Agreement in effect as of the date of the NSF grant award, rather than using the rates included within the original grant proposal.	$0	$0	9/30/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-009	University of New Mexico (5/13/2021)	3.2) Direct UNM to require subawardees to apply indirect costs using the rates that were established in the Negotiated Indirect Cost Rate Agreement in effect as of the date of the subaward agreement, rather than using the rates included within the subaward budget and proposal.	$0	$0	9/30/2022
21-1-015	University of Central Florida (5/27/2021)	1.1) Direct UCF to provide documentation supporting that it has repaid or otherwise credited the $134 in questioned fringe benefit costs for which it has agreed to reimburse NSF.	$ 134	$0	9/14/2022
21-1-015	University of Central Florida (5/27/2021)	1.2) Direct UCF to notify its federal sponsors that its personnel have not yet certified their effort for the Fall 2019, Spring 2020, Summer 2020, and Fall 2020 semesters.	$0	$0	9/14/2022
21-1-015	University of Central Florida (5/27/2021)	1.3) Direct UCF to require its employees to certify their effort for the Fall 2019, Spring 2020, Summer 2020, and Fall 2020 semesters and then process any cost transfers needed to ensure that UCF charged NSF for salary costs that were consistent with the effort certified.	$0	$0	9/14/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-015	University of Central Florida (5/27/2021)	1.4) Direct UCF to review all salary earned during June 2020 to verify that its accounting system appropriately applied fringe benefits at the correct rate and, if the accounting system did not apply fringe benefits at the correct rate, process any adjustments necessary.	$0	$0	9/14/2022
21-1-015	University of Central Florida (5/27/2021)	2.1) Direct UCF to provide documentation supporting that it has repaid or otherwise credited the $160 of questioned participant support costs for which it has agreed to reimburse NSF.	$ 314	$0	9/14/2022
21-1-015	University of Central Florida (5/27/2021)	2.2) Direct UCF to establish policies and procedures to ensure that it obtains and documents proper approval for insurance costs before charging the costs to NSF awards.	$0	$0	9/14/2022
21-1-015	University of Central Florida (5/27/2021)	2.3) Direct UCF to establish policies and procedures to ensure that it does not apply fringe benefit rates to participant support costs that it processes through its payroll subledger.	$0	$0	9/14/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-015	University of Central Florida (5/27/2021)	3.1) Directing UCF to implement additional monitoring procedures to ensure that it uses travel credits to benefit the NSF award(s) to which it charged the original travel expense. For cases in which UCF uses a credit to benefit other project(s), it should monitor to ensure that the original travel expense is transferred to the appropriate funding source.	$0	$0	9/14/2022
21-1-016	University of South Carolina Columbia (6/29/2021)	1.1) Direct UofSC to provide documentation supporting that it has repaid or otherwise credited the $93,738 of questioned equipment, material, and supply costs	$ 93,738	$0	1/11/2023
21-1-016	University of South Carolina Columbia (6/29/2021)	1.2) Direct UofSC to strengthen the administrative and management controls, training, processes, and procedures over expenditures near the end of an award	$0	$0	1/11/2023
21-1-016	University of South Carolina Columbia (6/29/2021)	2.1) Direct UofSC to provide documentation supporting that it has repaid or otherwise credited the $25,277 of questioned unsupported costs	$ 25,277	$0	1/11/2023
21-1-016	University of South Carolina Columbia (6/29/2021)	2.2) Direct UofSC to strengthen the administrative and management controls, training, processes, and procedures related to document retention	$0	$0	1/11/2023

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-016	University of South Carolina Columbia (6/29/2021)	3.1) Direct UofSC to provide documentation supporting that it has repaid or otherwise credited the $20,883 of questioned unallocable and unreasonable costs	$ 20,883	$0	1/11/2023
21-1-016	University of South Carolina Columbia (6/29/2021)	3.2) Direct UofSC to strengthen the administrative and management controls, training, processes, and review procedures for the NSF award expenditures	$0	$0	1/11/2023
21-1-016	University of South Carolina Columbia (6/29/2021)	4.1) Direct UofSC to provide documentation supporting that it has repaid or otherwise credited the $462 of questioned currency conversion costs	$0	$0	1/11/2023
21-1-016	University of South Carolina Columbia (6/29/2021)	4.2) Direct UofSC to strengthen processes for reviewing and approving costs charged to NSF awards	$0	TBD	1/11/2023
21-1-018	Regents of the University of Michigan Ann Arbor (8/2/2021)	1.1) Direct UM to provide documentation supporting that it has repaid or otherwise credited the $11,499 of questioned participant support costs for which it has agreed to reimburse NSF.	$ 11,499	$0	9/26/2022
21-1-018	Regents of the University of Michigan Ann Arbor (8/2/2021)	1.2) Direct UM to establish clear guidance regarding the rebudgeting of participant support cost funding. This guidance should address when and how to request approval to rebudget participant support cost funding, as well as how to document the approval.	$0	$0	9/26/2022

OIG Report Number	Audited Entity (Report Issue Date)	Recommendation	Costs Disallowed	Costs Allowed	Date Resolved
21-1-018	Regents of the University of Michigan Ann Arbor (8/2/2021)	2.1) Direct UM to update its current award set-up practices to require that, when setting up accounts established for NSF awards and/or funding supplements, personnel ensure that the accounts apply indirect costs using the rate(s) that were established in the Negotiated Indirect Cost Rate Agreement in effect as of the date of the NSF award, rather than using the rate(s) included in the original Notice of Award.	$0	$0	9/26/2022
21-1-018	Regents of the University of Michigan Ann Arbor (8/2/2021)	3.1) Direct UM to implement additional monitoring procedures to ensure that it uses any travel credits received to benefit the NSF award(s) to which UM charged the original travel expense. For cases in which UM uses a travel credit to benefit other project(s), it should monitor to ensure that personnel transfer the original travel expense to the appropriate funding source(s).	$0	$0	9/26/2022

TECHNICAL INFORMATION

For definitions of common acronyms used throughout NSF's FY 2024 Budget Request, see the NOTES found at the beginning of the entire document on pages iii-iv.

FY 2024 APPROPRIATIONS LANGUAGE

National Science Foundation

RESEARCH AND RELATED ACTIVITIES

For necessary expenses in carrying out the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), and Public Law 86–209 (42 U.S.C. 1880 et seq.); services as authorized by section 3109 of title 5, United States Code; maintenance and operation of aircraft and purchase of flight services for research support; acquisition of aircraft; and authorized travel; ~~$7,021,136,000~~$9,017,900,000, to remain available until September 30, ~~2024~~2025, of which not to exceed ~~$640,000,000~~$700,000,000 shall remain available until expended for polar research and operations support, and for reimbursement to other Federal agencies for operational and science support and logistical and other related activities for the United States Antarctic program: Provided, That receipts for scientific support services and materials furnished by the National Research Centers and other National Science Foundation supported research facilities may be credited to this appropriation. (Science Appropriations Act, 2023.)

~~RESEARCH AND RELATED ACTIVITIES~~

~~For an additional amount for "Research and Related Activities" for necessary expenses related to damage to research facilities and scientific equipment in calendar year 2022, including related to the consequences of wildfires, $2,500,000, to remain available until September 30, 2024. For an additional amount for "Research and Related Activities", $818,162,000, to remain available until September 30, 2024, of which $210,000,000 shall be to implement the Research and Development, Competition, and Innovation Act (division B of Public Law 117–167). (Disaster Relief Supplemental Appropriations Act, 2023.)~~

STEM EDUCATION

For necessary expenses in carrying out science, mathematics, and engineering education and human resources programs and activities pursuant to the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), including services as authorized by section 3109 of title 5, United States Code, authorized travel, and rental of conference rooms in the District of Columbia, ~~$1,154,000,000~~$1,496,180,000, to remain available until September 30, ~~2024~~2025. (Science Appropriations Act, 2023.)

~~STEM EDUCATION~~

~~For an additional amount for "STEM Education", $217,000,000, to remain available until September 30, 2024, of which $125,000,000 shall be to implement the Research and Development, Competition, and Innovation Act (division B of Public Law 117–167). (Disaster Relief Supplemental Appropriations Act, 2023.)~~

AGENCY OPERATIONS AND AWARD MANAGEMENT

For agency operations and award management necessary in carrying out the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.); services authorized by section 3109 of title 5, United States Code; hire of passenger motor vehicles; uniforms or allowances therefor, as authorized by

sections 5901 and 5902 of title 5, United States Code; rental of conference rooms in the District of Columbia; and reimbursement of the Department of Homeland Security for security guard services; ~~$448,000,000~~$503,870,000: Provided, That not to exceed $8,280 is for official reception and representation expenses: Provided further, That contracts may be entered into under this heading in fiscal year ~~2023~~2024 for maintenance and operation of facilities and for other services to be provided during the next fiscal year. (Science Appropriations Act, 2023.)

OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, ~~$23,393,000~~$26,810,000, of which $400,000 shall remain available until September 30, ~~2024~~2025. (Science Appropriations Act, 2023.)

OFFICE OF THE NATIONAL SCIENCE BOARD

For necessary expenses (including payment of salaries, authorized travel, hire of passenger motor vehicles, the rental of conference rooms in the District of Columbia, and the employment of experts and consultants under section 3109 of title 5, United States Code) involved in carrying out section 4 of the National Science Foundation Act of 1950 (42 U.S.C. 1863) and Public Law 86–209 (42 U.S.C. 1880 et seq.), ~~$5,090,000~~$5,250,000: Provided, That not to exceed $2,500 shall be available for official reception and representation expenses. (Science Appropriations Act, 2023.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

For necessary expenses for the acquisition, construction, commissioning, and upgrading of major research equipment, facilities, and other such capital assets pursuant to the National Science Foundation Act o f1950 (42 U.S.C.1861 et seq.), including authorized travel, ~~$187,230,000~~$304,670,000, to remain available until expended. (Science Appropriations Act, 2023.)

ADMINISTRATIVE PROVISIONS
(INCLUDING TRANSFER OF FUNDS)

Not to exceed 5 percent of any appropriation made available for the current fiscal year for the National Science Foundation in this Act may be transferred between such appropriations, but no such appropriation shall be increased by more than 10 percent by any such transfers. Any transfer pursuant to this paragraph shall be treated as a reprogramming of funds under section 504 of this Act and shall not be available for obligation except in compliance with the procedures set forth in that section.

The Director of the National Science Foundation (NSF) shall notify the Committees on Appropriations of the House of Representatives and the Senate at least 30 days in advance of any planned divestment through transfer, decommissioning, termination, or deconstruction of any NSF-owned facilities or any NSF capital assets (including land, structures, and equipment) valued greater than $2,500,000.

NATIONAL SCIENCE FOUNDATION
SUMMARY OF FY 2024 BUDGETARY RESOURCES BY ACCOUNT
(Dollars in Millions)

Discretionary Accounts	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request REVISED	Change Over FY 2023 Enacted Amount	Change Over FY 2023 Enacted Percent
RESEARCH AND RELATED ACTIVITIES					
Appropriation	$7,159.40	$7,841.80	$9,017.90	$1,176.10	15.00%
Unobligated Balance Available Start of Year	292.79	72.02		-72.02	
Unobligated Balance Available End of Year	-72.02				
Adjustments to Prior Year Accounts[1]	21.49				
Subtotal, R&RA	**$7,401.66**	**$7,913.82**	**$9,017.90**		
Transfer to/from other funds	-159.88	-15.00			
Total Budgetary Resources	**$7,241.78**	**$7,898.82**	**$9,017.90**	**$1,119.08**	**14.17%**
STEM EDUCATION					
Appropriation	1,006.00	1,371.00	1,496.18	125.18	9.13%
Unobligated Balance Available Start of Year	44.60	10.97		-10.97	
Unobligated Balance Available End of Year	-10.97				
Adjustments to Prior Year Accounts[1]	0.64				
Subtotal, EDU	**$1,040.27**	**$1,381.97**	**$1,496.18**		
Transfer to/from other funds	143.46				
Total Budgetary Resources	**$1,183.73**	**$1,381.97**	**$1,496.18**	**$114.21**	**8.26%**

Totals exclude reimbursable amounts.

[1]Adjustments include upward and downward adjustments to prior year obligations in unexpired accounts.

NATIONAL SCIENCE FOUNDATION
SUMMARY OF FY 2024 BUDGETARY RESOURCES BY ACCOUNT
(Dollars in Millions)

Discretionary Accounts	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request	Change Over FY 2023 Enacted Amount	Change Over FY 2023 Enacted Percent
MAJOR RESEARCH EQUIPMENT & FACILITIES CONSTRUCTION					
Appropriation	$274.00	$187.23	$304.67	$117.44	62.70%
Unobligated Balance Available Start of Year	260.31	330.73		-330.73	
Unobligated Balance Available End of Year	-330.73				
Adjustments to Prior Year Accounts[1]	-4.52				
Subtotal, MREFC	**$199.06**	**$517.96**	**$304.67**		
Transfer to/from other funds	-8.48				
Total Budgetary Resources	**$190.58**	**$517.96**	**$304.67**	**-$213.29**	**-41.20%**
AGENCY OPERATIONS AND AWARD MANAGEMENT					
Appropriation	400.00	448.00	503.87	55.87	12.50%
Unobligated Balance Available Start of Year	-	4.40		-4.40	
Unobligated Balance Available End of Year	-4.40				
Adjustments to Prior Year Accounts[1]	-0.29				
Subtotal, AOAM	**$395.31**	**$452.40**	**$503.87**		
Transfer to/from other funds	24.9	15.00			
Total Budgetary Resources	**$420.21**	**$467.40**	**$503.87**	**$36.47**	**7.80%**
NATIONAL SCIENCE BOARD					
Appropriation	4.60	5.09	5.25	0.16	3.10%
Unobligated Balance - Expired	-0.08				
Total Budgetary Resources	**$4.52**	**$5.09**	**$5.25**	**$0.16**	**3.10%**

Totals exclude reimbursable amounts.

[1]Adjustments include upward and downward adjustments to prior year obligations in unexpired accounts.

NATIONAL SCIENCE FOUNDATION
SUMMARY OF FY 2024 BUDGETARY RESOURCES BY ACCOUNT
(Dollars in Millions)

Discretionary Accounts	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request REVISED	Change Over FY 2023 Enacted Amount	Change Over FY 2023 Enacted Percent
OFFICE OF INSPECTOR GENERAL					
Appropriation	$19.00	$23.39	$26.81	$3.42	14.60%
Unobligated Balance Available Start of Year	0.40	0.40		-0.40	
Unobligated Balance Available End of Year	-0.40				
Unobligated Balance - Expired	-0.11				
Total Budgetary Resources	**$18.89**	**$23.79**	**$26.81**	**$3.02**	**12.70%**
TOTAL DISCRETIONARY, NATIONAL SCIENCE FOUNDATION	$9,059.71	$10,295.03	$11,354.68	$1,059.65	10.29%

Totals exclude reimbursable amounts.

[1]Adjustments include upward and downward adjustments to prior year obligations in unexpired accounts.

NATIONAL SCIENCE FOUNDATION
SUMMARY OF FY 2024 BUDGETARY RESOURCES BY ACCOUNT
(Dollars in Millions)

Mandatory Accounts	FY 2022 Actual	FY 2023 Enacted	FY 2024 Request	Change Over FY 2023 Enacted Amount	Change Over FY 2023 Enacted Percent
STEM EDUCATION, H-1B					
Appropriation, Mandatory (H-1B Non-Immigrant Petitioner Fees)	$189.94	$192.54	$198.84	$6.30	3.30%
Unobligated Balance Available Start of Year	141.78	51.15		-51.15	
Sequestration Previously Unavailable	8.75	10.83	10.97	0.14	
Sequestration Pursuant OMB M-13-06	-10.83	-10.97	-11.33		
Unobligated Balance Available End of Year	-51.15				
Total Budgetary Resources	**$278.48**	**$243.55**	**$198.48**	**-$45.07**	**-18.50%**
Creating Helpful Incentives to Produce Semiconductors (CHIPS) for American Workforce and Education					
Appropriation, Mandatory (CHIPS H.R. 4346)	-	25.00	25.00	-	-
Total Budgetary Resources	**-**	**$25.00**	**$25.00**	**-**	**-**
DONATIONS					
Mandatory Programs (Special or Trust Fund)	20.23	40.00	40.00	-	-
Unobligated Balance Available Start of Year	10.89	24.10		-24.10	
Unobligated Balance Available End of Year	-24.10				
Total Budgetary Resources	**7.02**	**64.10**	**40.00**	**-24.10**	**-37.60%**
TOTAL MANDATORY, NATIONAL SCIENCE FOUNDATION	**285.50**	**332.65**	**263.48**	**-69.17**	**-$0.56**

Totals exclude reimbursable amounts.

[1]Adjustments include upward and downward adjustments to prior year obligations in unexpired accounts.

NSF FY 2024 REQUEST FUNDING BY PROGRAM
(Dollars in Millions)

			Disaster Relief Supplemental					FY 2024 Request change over FY 2023 Base Total	
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS and Science	RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request	Amount	Percent
BIOLOGICAL SCIENCES (BIO)									
BIOLOGICAL INFRASTRUCTURE	$197.20	$208.50	-	-	-	$208.50	$227.92	$19.42	9.3%
EMERGING FRONTIERS	89.17	108.97	25.25	-	-	134.22	183.96	49.74	37.1%
ENVIRONMENTAL BIOLOGY	180.10	169.81	-	-	-	169.81	188.55	18.74	11.0%
INTEGRATIVE ORGANISMAL SYSTEMS	208.40	197.45	-	-	-	197.45	214.96	17.51	8.9%
MOLECULAR & CELLULAR BIOSCIENCES	156.74	147.00	-	-	-	147.00	157.02	10.02	6.8%
TOTAL, BIO	**$831.61**	**$831.73**	**$25.25**	**-**	**-**	**$856.98**	**$972.41**	**$115.43**	**13.5%**
COMPUTER & INFORMATION SCIENCE & ENGINEERING (CISE)									
ADVANCED CYBER INFRASTRUCTURE	230.52	230.54	22.00	-	-	252.54	282.54	30.00	11.9%
COMPUTING & COMMUNICATION FOUNDATIONS	201.06	200.00	3.00	-	-	203.00	224.21	21.21	10.4%
COMPUTER & NETWORK SYSTEMS	243.10	241.12	8.00	-	-	249.12	281.23	32.11	12.9%
INFORMATION & INTELLIGENT SYSTEMS	217.85	218.87	2.00	-	-	220.87	254.12	33.25	15.1%
INFORMATION TECHNOLOGY RESEARCH	122.20	120.04	5.00	-	-	125.04	130.04	5.00	4.0%
TOTAL, CISE	**$1,014.72**	**$1,010.57**	**$40.00**	**-**	**-**	**$1,050.57**	**$1,172.14**	**$121.57**	**11.6%**
ENGINEERING (ENG)[1,2]									
CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, & TRANSPORT SYSTEMS	203.42	203.45	-	-	-	203.45	214.99	11.54	5.7%
CIVIL, MECHANICAL, & MANUFACTURING INNOVATION	239.28	239.30	-	-	-	239.30	252.87	13.57	5.7%
ELECTRICAL, COMMUNICATIONS, & CYBER SYSTEMS	123.10	123.11	-	-	-	123.11	130.09	6.98	5.7%
EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES	76.19	74.87	34.00	-	-	108.87	215.82	106.95	98.2%
ENGINEERING EDUCATION & CENTERS	132.55	134.07	-	-	-	134.07	156.23	22.16	16.5%
TOTAL, ENG	**$774.53**	**$774.80**	**$34.00**	**-**	**-**	**$808.80**	**$970.00**	**$161.20**	**19.9%**
GEOSCIENCES (GEO)									
ATMOSPHERIC & GEOSPACE SCIENCES	288.17	288.00	5.89	-	-	293.89	318.61	24.72	8.4%
EARTH SCIENCES	202.41	202.11	2.00	-	-	204.11	213.15	9.04	4.4%
RESEARCH, INNOVATION, SYNERGIES and EDUCATION	126.34	125.10	11.57	-	-	136.67	257.19	120.52	88.2%
OCEAN SCIENCES	418.81	417.05	16.43	-	-	433.48	447.43	13.95	3.2%
TOTAL, GEO	**$1,035.73**	**$1,032.26**	**$35.89**	**-**	**-**	**$1,068.15**	**$1,236.38**	**$168.23**	**15.7%**

NSF FY 2024 REQUEST FUNDING BY PROGRAM
(Dollars in Millions)

			Disaster Relief Supplemental					FY 2024 Request REVISED change over FY 2023 Base Total	
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS and Science	RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request REVISED	Amount	Percent
MATHEMATICAL & PHYSICAL SCIENCES (MPS)									
ASTRONOMICAL SCIENCES	283.61	283.57	8.76	-	-	292.33	303.33	11.00	3.8%
CHEMISTRY	265.19	264.46	4.37	-	-	268.83	279.83	11.00	4.1%
MATERIALS RESEARCH	338.75	338.78	0.63	-	-	339.41	350.41	11.00	3.2%
MATHEMATICAL SCIENCES	248.32	247.99	4.00	-	-	251.99	262.99	11.00	4.4%
PHYSICS	309.89	308.90	4.23	-	-	313.13	324.13	11.00	3.5%
MULTIDISCIPLINARY ACTIVITIES	169.51	169.20	48.45	-	2.50	220.15	315.10	97.45	44.8%
TOTAL, MPS	**$1,615.26**	**$1,612.90**	**$70.44**	**-**	**$2.50**	**$1,685.84**	**$1,835.79**	**$152.45**	**9.1%**
SOCIAL, BEHAVIORAL & ECONOMIC SCIENCES (SBE)									
BEHAVIORAL AND COGNITIVE SCIENCES	102.69	102.70	1.00	-	-	103.70	120.41	16.71	16.1%
SOCIAL AND ECONOMIC SCIENCES	104.11	104.12	1.00	-	-	105.12	121.83	16.71	15.9%
MULTIDISCIPLINARY ACTIVITIES	22.55	22.49	3.00	-	-	25.49	28.12	2.63	10.3%
NATIONAL CENTER FOR SCIENCE & ENGINEERING STATISTICS	56.51	56.51	22.38	-	-	78.89	90.24	11.35	14.4%
TOTAL, SBE	**$285.86**	**$285.82**	**$27.38**	**-**	**-**	**$313.20**	**$360.60**	**$47.40**	**15.1%**
TECHNOLOGY, INNOVATION & PARTNERSHIPS (TIP)[2]									
TRANSLATIONAL IMPACT (TI)	334.86	171.00	220.00	10.00	-	401.00	488.64	97.64	25.0%
[SBIR/STTR, including operations]	*[235.68]*	*[46.54]*	*[220.00]*	-	-	[266.54]	[304.18]	[37.64]	[14.1%]
INNOVATION & TECHNOLOGY ECOSYSTEMS	78.23	149.00	-	200.00	-	349.00	490.00	341.00	228.9%
TECHNOLOGY FRONTIERS	-	129.80	-	-	-	129.80	196.80	67.00	51.6%
STRATEGIC PARTNERSHIPS OFFICE	-	0.20	-	-	-	0.20	10.19	9.99	4995.0%
TOTAL, TIP	**$413.09**	**$450.00**	**$220.00**	**$210.00**	**-**	**$880.00**	**$1,185.63**	**$515.63**	**77.0%**
OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING (OISE)	**$54.23**	**$61.32**	**$8.00**	**-**	**-**	**$69.32**	**$71.21**	**$1.89**	**2.7%**
OFFICE OF POLAR PROGRAMS (OPP)									
OFFICE OF POLAR PROGRAMS	544.68	545.16	-	-	-	545.16	565.60	20.44	3.7%
[US Antarctic Logistical Support Activities]	*[85.00]*	*[94.20]*	-	-	-	*[94.20]*	*[102.00]*	*[7.80]*	*[8.3%]*
Total, OPP	**$544.68**	**$545.16**	**-**	**-**	**-**	**$545.16**	**$565.60**	**$20.44**	**3.7%**
INTEGRATIVE ACTIVITIES (IA)									
ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR)	215.06	205.00	50.00	-	-	255.00	280.68	25.68	10.1%
INTEGRATIVE ACTIVITIES[3]	178.24	194.83	97.20	-	-	292.03	365.69	73.66	25.2%
TOTAL, IA	**$393.30**	**$399.83**	**$147.20**	**-**	**-**	**$547.03**	**$646.37**	**$99.34**	**18.2%**

			Disaster Relief Supplemental					FY 2024 Request REVISED change over FY 2023 Base Total	
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS and Science	RI Damage Mitigation	FY 2023 Estimate Total	FY 2024 Request REVISED	Amount	Percent
UNITED STATES ARCTIC RESEARCH COMMISSION	**$1.66**	**$1.75**	**-**	**-**	**-**	**$1.75**	**$1.77**	**$0.02**	**1.1%**
TOTAL, RESEARCH AND RELATED ACTIVITIES	**$6,964.66**	**$7,006.14**	**$608.16**	**$210.00**	**$2.50**	**$7,826.80**	**$9,017.90**	**$1,403.60**	**18.4%**
STEM EDUCATION (EDU)									
GRADUATE EDUCATION[3]	432.11	396.12	92.00	40.00	-	528.12	563.18	75.06	15.4%
EQUITY FOR EXCELLENCE IN STEM	227.03	254.76	-	23.00	-	277.76	326.32	71.56	28.1%
RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS	211.98	223.02	-	26.90	-	249.92	255.33	32.31	14.5%
UNDERGRADUATE EDUCATION	275.60	280.10	-	35.10	-	315.20	351.35	71.25	25.4%
TOTAL, STEM EDUCATION	**$1,146.72**	**$1,154.00**	**$92.00**	**$125.00**	**-**	**$1,371.00**	**$1,496.18**	**$250.18**	**20.1%**
MAJOR RESEARCH EQUIPMENT & FACILITIES CONSTRUCTION[4]	**$120.60**	**$187.23**	**-**	**-**	**-**	**$187.23**	**$304.67**	**$117.44**	**62.7%**
AGENCY OPERATIONS AND AWARD MANAGEMENT	**$420.21**	**$463.00**	**-**	**-**	**-**	**$463.00**	**$503.87**	**$40.87**	**8.8%**
OFFICE OF INSPECTOR GENERAL	**$18.89**	**$23.39**	**-**	**-**	**-**	**$23.39**	**$26.81**	**$3.42**	**14.6%**
OFFICE OF THE NATIONAL SCIENCE BOARD	**$4.52**	**$5.09**	**-**	**-**	**-**	**$5.09**	**$5.25**	**$0.16**	**3.1%**
TOTAL, NATIONAL SCIENCE FOUNDATION	**$8,675.60**	**$8,838.85**	**$700.16**	**$335.00**	**$2.50**	**$9,876.51**	**$11,354.68**	**$1,815.67**	**19.0%**

[1] The division of Industrial Innovation and Partnerships (IIP) is being dissolved in FY 2022, with the bulk of it programs moving to the New Directorate for Technology, Innovation and Partnerships (TIP) and the remainder to EEC. Funding above is presented in the new structure across all fiscal years for comparability.

[2] FY 2021 funding is adjusted for comparability to reflect the movement of activities to TIP in FY 2022.

[3] The Graduate Research Fellowship Program is consolidated within the EDU Division of Graduate Education in FY 2022 and is restated in prior years for comparability.

[4] Excludes $360.65 million provided by the American Rescue Plan supplemental appropriation and $23.45 million provided by the "Extending Government Funding and Delivering Emergency Assistance Act", for necessary expenses related to RCRV construction impacted by Hurricane Ida.

OBJECT CLASSIFICATION
NSF Consolidated Obligations
(Dollars in Millions)

Object Class Code	Standard Title	FY 2022 Actual	FY 2023 Estimate[1]	FY 2024 Request REVISED
11.1	Full-time permanent	$203	$237	$258
11.3	Other than full-time permanent	14	14	14
11.5	Other personnel compensation	7	7	7
11.8	Special personal service payment	55	57	59
	Total personnel compensation	279	315	338
12.1	Civilian personnel benefits	78	88	98
21.0	Travel and transportation of persons	7	12	13
22.0	Transportation of things	1	1	2
23.1	Rental payments	33	27	33
23.2	Rental payments to others	1	1	1
23.3	Communications, utilities, and miscellaneous charges	-	1	-
25.1	Advisory and assistance services	251	254	259
25.2	Other services	51	73	72
25.3	Purchases of goods and services from Government	228	235	245
25.4	Operation and maintenance of facilities	274	300	300
25.5	Research and development contracts	16	16	17
25.7	Operation and maintenance of equipment	18	20	24
26.0	Supplies and materials	-	-	-
31.0	Equipment	6	7	7
41.0	Grants, subsidies, and contributions	7,818	8,968	9,971
	Total, Direct obligations[2]	**$9,061**	**$10,318**	**$11,380**

[1] This information differs from what is shown in the President's Budget Request which shows NSF's Enacted FY 2023 funding levels.

[2] Excludes obligations for mandatory and reimbursable accounts.

REIMBURSABLE ACTIVITY

Reimbursements for the Research and Related Activities Appropriation and the STEM Education (formerly Education and Human Resources) Appropriation are realized from other federal agencies that have entered into interagency agreements with the Foundation. NSF enters into agreements (including Memoranda of Understanding) with other U.S. government agencies, as authorized by the NSF Act, 42 U.S.C. 1870 (c), and the Economy Act, 31 U.S.C. 1535, under which NSF assumes some responsibility for activities supported by these agencies. These activities can include jointly funded projects and programs, support of research operations and logistics, and access to NSF supported research facilities.

NSF Reimbursements by Agency
(Dollars in Millions)

DEPARTMENT/AGENCY	FY 2022 Actual
DEFENSE	
Air Force	*$8.16*
Defense	*27.00*
Navy	*5.18*
Army	*3.98*
Subtotal, DoD	$44.32
Commerce (Including Census, NOAA, & NIST)	8.26
Interior	1.90
Energy	5.73
Health & Human Services	36.02
Homeland Security	1.60
NASA	5.03
Corps of Engineers, Civil	0.77
Transportation	0.52
Education	0.51
OTHER (less than $500,000)	1.34
TOTAL REIMBURSEMENTS	**$106.00**

Totals may not add due to rounding.

Consistent with applicable legislation and GAO decisions, agreements include reimbursement for costs that are incurred in the management and administration of these awards.

EXPLANATION OF FY 2022 CARRYOVER INTO FY 2023 BY ACCOUNT

The National Science Foundation's total unobligated balance of $493.78 million ($418.52 million from Discretionary accounts, and $75.26 million from Mandatory accounts) is described below.

Discretionary and Mandatory Accounts:

Distribution of NSF FY 2022 Carryover into FY 2023

(Dollars in Millions)

Discretionary Accounts	**Amount**
Research and Related Activities	$72.02
STEM Education	10.97
Major Research Equipment and Facilities Construction	330.73
Agency Operations and Award Management	4.40
Office of Inspector General	0.40
Total, Appropriated Accounts	**$418.52**
Mandatory Accounts	
H-1B Non-Immigrant Petitioner	51.15
Donations	24.10
Total, Mandatory	**$75.26**
TOTAL, NSF	**$493.78**

Appropriated Accounts

Research and Related Activities (R&RA)
Within the R&RA account, $72.02 million was carryover into FY 2023.

Directorate for Geosciences Polar Programs (no-year funding)
- Amount: $7.28 million
- Purpose: Recoveries from prior year obligations that were received too late in the fiscal year to obligate.
- Obligation: Anticipated FY 2023 Quarter 4

Integrative Activities for Evaluation and Assessment Capabilities program
- Amount: $1.06 million
- Purpose: Funds will be used for the Evaluation and Assessment Program Services contract in support of NSF's Learning Agenda and Annual Evaluation Plan and will be used to conduct evaluative studies such as the Merit Review bias analysis, Convergence Accelerator and EPSCoR.
- Obligation: Anticipated FY 2023 Quarter 1 and Quarter 2

Integrative Activities for Growing Convergence Research
- Amount: $453,000
- Purpose: Funds will support awards that were not ready for obligation in FY 2022.
- Obligation: Anticipated FY 2023 Quarter 2

Integrative Activities for Growing Research Access for Nationally Transformative Equity and Diversity
- Amount: $1.85 million
- Purpose: Funds will support conferences and workshops addressing the research administration and post-award management capabilities and capacity at under-resourced and emerging research institutions.
- Obligation: Anticipated FY 2023 Quarter 2

Integrative Activities for Historically Black Colleges & Universities – Excellence in Research (HBCU-EiR)
- Amount: $4.42 million
- Purpose: Funds will support awards associated with the HBCU-EiR proposal cycle that began in July 2022 including new opportunities announced in fall 2022.
- Obligation: Anticipated FY 2023 Quarter 3

Integrative Activities for Major Research Instrumentation
- Amount: $114,000
- Purpose: Funds will be used for awards that were not ready for obligation in FY 2022.
- Obligation: Anticipated FY 2023 Quarter 2

Integrative Activities for Mid-scale Research Infrastructure – Track 1
- Amount: $6,400
- Purpose: Funds will provide continuing support to projects that began in FY 2021 upon receipt of progress reports that are due late in FY 2022.
- Obligation: Anticipated FY 2023 Quarter 2

Integrative Activities for Science and Technology Centers Administration
- Amount: $7,700
- Purpose: Funds will provide support to a contractor for a summative study of the Science and Technology Centers program.
- Obligation: Anticipated FY 2023 Quarter 2

Integrative Activities for Modeling and Forecasting program
- Amount: $1.47 million
- Purpose: Funds will be used to develop an enterprise analytics governance/management operating model, conduct an organizational assessment, and develop an implementation plan.
- Obligation: Anticipated FY 2023 Quarter 2

Integrative Activities for Program Planning and Policy Development
- Amount: $643,000
- Purpose: Funds will support activities to enhance and expand opportunities for minority-serving and emerging research institutions, as well as support capacity-building activities for national priorities.
- Obligation: Anticipated by FY 2023 Quarter 3

Integrative Activities for Research Investment Communications
- Amount: $783,000
- Purpose: Funds will be used for NSF multimedia contract awards that were not ready for obligation in FY 2022. These funds will support critical communications contracts that enable NSF

to engage with stakeholders including Congress, elected officials, national and international institutions, and the general public.
- Obligation: Anticipated FY 2023 Quarter 2

Integrative Activities for Research Security Strategy and Policy
- Amount: $586,000
- Purpose: This funding will support NSF's analytic capabilities to proactively identify conflicts of commitment, vulnerabilities of pre-publication research, risks to the merit review system, and development and implementation of training — to recipients of federal research funding — for best practices to optimize research security.
- Obligation: Anticipated FY 2023 Quarter 1 and Quarter 2

Office of International Science & Engineering
- Amount: $5.24 million
- Purpose: Funds will be used for awards that were not ready for obligation in FY 2022 associated with cross-directorate collaborations that include international components and supporting the launch of OISE's Global Center program.
- Obligation: Anticipated FY 2023 Quarter 3

TIP Innovation & Technology Ecosystems
- Amount: $37.78 million
- Purpose: Given the timing of the establishment of the TIP directorate, the initiation of several activities was delayed, leaving insufficient time to complete the review process and make awards. Activities included aspects of the NSF Convergence Accelerator program, NSF Regional Innovation Engines (NSF Engines) program, the Democracy-Affirming Technologies Prize Challenges, and the Proto-Open Knowledge Networks (Proto-OKN) program
- Obligation: Anticipated FY 2023 Quarter 1, 2 and 3

TIP Translational Impacts:
- Amount: $3.0 million
- Purpose: Given the timing of the establishment of the TIP directorate, the initiation of the NSF Entrepreneurial Fellowships was delayed to Summer 2022, with initial funding split across FY 2022 and FY 2023.
- Obligation: Anticipated FY 2023 Quarters 1 and 2

TIP Translational Impacts (SBIR and STTR):
- Amount: $3.05 million
- Purpose: Funds will be used on STTR Phase I or Phase II awards in FY 2023.
- Obligation: Anticipated FY 2023 Quarters 1 and 2

National Coordination Office for Networking and Information Technology Research and Development
- Amount: $934,000
- Purpose: Funds will continue government procurements and operational expenses (i.e. credit card purchases, government travel, mailroom operations, etc.).
- Obligation: Anticipated FY 2023 Quarter 2

National Nanotechnology Coordination Office
- Amount: $537,000
- Purpose: Funds will be used to fund the required Quadrennial Review of the National Nanotechnology Initiative. In addition, funds carried over will be used to cover rent in NNCO's new location and other operational costs.
- Obligation: Anticipated FY 2023 Quarter 2 and 3

The remaining $2.81 million within R&RA consists of funds from throughout the Foundation for projects not funded in FY 2022.

STEM Education (EDU)
Within the STEM account, $10.97 million was carried over into FY 2023.

EDU Core Research
- Amount: $13,496
- Purpose: To support actions that could not be processed in time.
- Obligation: Anticipated FY 2023 Quarter 1

Presidential Award for Excellence and Teaching
- Amount: $4.72 million
- Purpose: Applicant selection was delayed; therefore, the carryover amount will be used to recognize recipients of the Presidential Awards for Excellence in Mathematics, Science Teaching and recipients of the Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring.
- Obligation: Anticipated FY 2023 Quarter 2

Robert Noyce Teacher Scholarship Program (Noyce)
- Amount: $4.30 million
- Purpose: This no year account will use carryover to invest in teacher preparation and/or support Noyce fellows during completion of a teaching obligation.
- Obligation: Anticipated FY 2023 Quarter 1

The remaining $1.94 million consists of funds from EDU for projects not funded in FY 2022.

Major Research Equipment and Facilities Construction (MREFC)
Within the MREFC account, $330.73 million was carried over into FY 2023.

Mid-scale Research Infrastructure Track 2 (Mid-scale RI-2)
- Amount: $98.34 million
- Purpose: Obligations proceeding as anticipated. This portfolio has both out-year mortgages on current awards and future obligations planned on pending awards given the two-year proposal/review cycle. Availability of an additional $6.50 million in targeted appropriations through ARP also reduced need for previously appropriated funds. Obligations for the next round of proposals (some of which are approaching $100.0 million) will be made following NSB authorization of the portfolio in February 2023.
- Obligation: Anticipated $60.0 million FY 2023 Quarter 2; $38.0 million FY 2023 Quarter 4

Antarctic Infrastructure Modernization for Science (AIMS)
(as described in the Antarctic Infrastructure Recapitalization narrative of the MREFC chapter)

- Amount: $150.65 million
- Purpose: Continued construction of the Antarctic Infrastructure Modernization for Science (AIMS) project. Any residual funds not needed for AIMS will be carried over into the Antarctic Infrastructure Recapitalization (AIR) program to potentially support unfunded components of AIMS or other recapitalization priorities.
- Obligation: Anticipated $100.0 million in FY 2023; $50.65 million in FY 2024

Regional Class Research Vessel (RCRV), Including $1.50 million in Hurricane Ida funding

- Amount: $6.50 million
- Purpose: Continued construction of the Regional Class Research Vessels. Management reserve funding not obligated in FY 2022.
- Obligation: Anticipated $5.0 million in FY 2023 based on project needs

Daniel K. Inouye Solar Telescope (DKIST)

- Amount: $20,467
- Purpose: Continued construction of the Daniel K. Inouye Solar Telescope (DKIST) Management reserve funding not obligated in FY 2021.
- Obligation: Construction completed. No additional obligations anticipated.

High Luminosity Large Hadron Collider (HL-LHC)

- Amount: $29.68 million
- Purpose: Continued construction of the Large Hadron Collider, High-Luminosity Upgrade (HL-LHC) program. Funding not obligated in FY 2022, including budget contingency.
- Obligation: Anticipated FY 2023 Quarter 2

Vera C. Rubin Observatory

- Amount: $40.0 million
- Purpose: Continued construction of the Vera C. Rubin Observatory following re-baseline
- Obligation: $29.0 million in FY 2024; $20.0 million in NSF-held management reserve to be obligated based on need.

Large Facilities Office

- Amount: $1.18 million
- Purpose: Enhanced Research Infrastructure oversight related to construction, acquisition, and implementation based on statutory and NSF policy requirements
- Obligation: Anticipated FY 2023 Quarter 1 and Quarter 2

The remaining $4.36 million consists of funds from recoveries from old projects not funded in FY 2022.

<u>Agency Operations and Award Management (AOAM)</u>
Within the AOAM account, $4.40 million was carried over into FY 2023.

- Amount: $4.40 million
- Purpose: To ensure sufficient funding would be available early in FY 2023 to bridge increased costs while operating under a Continuing Resolution for increased staffing as NSF is adding

additional FTE to manage increased responsibilities and requirements from CHIPS and Science Act, including staffing up a new directorate and several new offices, as well as ensuring funds are available to cover emerging needs in activities funded under the Office of Equity and Compliance in Research (OECR).
- Obligation: FY 2023 Quarter 1

Office of Inspector General (OIG)
Within the OIG two-year account, $398,292 was carryover over into FY 2023.
- Amount: $398,292
- Purpose: Funds are expected to be used to procure financial and performance audit services. The selection of awards and institutions to be audited will require careful preparation and is subject to changing circumstances and new information that may require additional time to process.
- Obligation: Anticipated FY 2023 Quarter 3

Mandatory

Within the H-1B account, $51.15 million was carryover into FY 2023.

Innovation Technology Experiences for Students and Teachers
- Amount: $30.91 million
- Purpose: Since NSF received the largest payments of H-1B visa fees in August and September, there was insufficient time to obligate the receipts on awards before the end of the fiscal year.
- Obligation: Anticipated FY 2023 Quarters 1-2

Scholarships in Science, Technology, Engineering, and Mathematics
- Amount: $6.76 million
- Purpose: Since NSF received the largest payments of H-1B visa fees in August and September, there was insufficient time to obligate the receipts on awards before the end of the fiscal year.
- Obligation: Anticipated FY 2023 Quarters 1-2

The remaining $13.48 million consists of funds from H-1B for projects not funded in FY 2022.

Within the Donations account, $24.10 million was for carryover into FY 2023. Donations are received from organizations and individuals to fund various cooperative efforts in science, research, and education.

QUANTITATIVE DATA TABLE

National Science Foundation

Research and Development Special Analysis

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental			FY 2023 Total	FY 2024 Request REVISED
			Base	CHIPS and Science	RI Damage Mitigation		
Investment Activities							
Conduct of Research and Development							
Basic Research	$5,630.17	$5,700.08	$313.47	$120.90	-	$6,134.45	$7,054.58
Applied Research	907.60	929.50	196.47	162.00	-	1,287.97	1,572.96
Subtotal, Conduct of R&D	6,537.77	6,629.58	509.94	282.90	-	7,422.42	8,627.54
Physical Assets							
Research and Development Facilities	141.17	207.24	0.46	-	2.50	210.20	339.53
Research and Development Major Equipment	301.72	303.98	41.55	-	-	345.53	339.06
Subtotal, R&D Facilities & Major Equipment	442.89	511.22	42.01	-	2.50	555.73	678.59
Total, Research and Development	6,980.66	7,140.80	551.95	282.90	2.50	7,978.15	9,306.13
Conduct of Education and Training	752.33	747.33	99.44	46.00	-	892.77	917.42
Non-Investment Activities	942.61	975.72	48.77	6.10	-	1,030.59	1,156.13
TOTAL	**$8,675.61**	**$8,863.85**	**$700.16**	**$335.00**	**$2.50**	**$9,901.51**	**$11,379.68**

[1]Excludes $360.65 million provided by the American Rescue Plan supplemental appropriation.

QUANTITATIVE DATA TABLE

RESEARCH AND RELATED ACTIVITIES

Research and Development Special Analysis

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental			FY 2023 Total	FY 2024 Request REVISED
			Base	CHIPS and Science	RI Damage Mitigation		
Investment Activities							
Conduct of Research and Development							
Basic Research	$5,455.54	$5,499.76	$313.47	$100.90	-	$5,914.13	$6,772.56
Applied Research	594.61	587.41	196.47	107.00	-	890.88	1,119.80
Subtotal, Conduct of R&D	6,050.15	6,087.17	509.94	207.90	-	6,805.01	7,892.36
Physical Assets							
Research and Development Facilities	20.57	20.01	0.46	-	2.50	22.97	34.86
Research and Development Major Equipment	301.72	303.98	41.55	-	-	345.53	339.06
Subtotal, R&D Facilities & Major Equipment	322.29	323.99	42.01	-	2.50	368.50	373.92
Total, Research and Development	6,372.44	6,411.16	551.95	207.90	2.50	7,173.51	8,266.28
Conduct of Education and Training	148.59	166.10	7.44	-	-	173.54	196.98
Non-Investment Activities	443.63	428.88	48.77	2.10	-	479.75	554.64
TOTAL	**$6,964.66**	**$7,006.14**	**$608.16**	**$210.00**	**$2.50**	**$7,826.80**	**$9,017.90**

[1]Excludes $277.11 million provided by the American Rescue Plan supplemental appropriation.

QUANTITATIVE DATA TABLE

STEM EDUCATION

Research and Development Special Analysis

(Dollars in Millions)

	FY 2022 Actual[1]	FY 2023 Estimate Base	Disaster Relief Supplemental			FY 2023 Total	FY 2024 Request REVISED
			Base	CHIPS and Science	RI Damage Mitigation		
Investment Activities							
Conduct of Research and Development							
Basic Research	$174.63	$188.32	-	$20.00	-	$208.32	$270.02
Applied Research	312.99	336.09	-	55.00	-	391.09	448.16
Subtotal, Conduct of R&D	487.62	524.41	-	75.00	-	599.41	718.18
Physical Assets							
Research and Development Facilities	-	-	-	-	-	-	-
Research and Development Major Equipment	-	-	-	-	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-	-	-	-	-
Total, Research and Development	487.62	524.41	-	75.00	-	599.41	718.18
Conduct of Education and Training	603.74	574.23	92.00	46.00	-	712.23	712.44
Non-Investment Activities	55.36	55.36	-	4.00	-	59.36	65.56
TOTAL	**$1,146.72**	**$1,154.00**	**$92.00**	**$125.00**	**-**	**$1,371.00**	**$1,496.18**

[1]Excludes $37.01 million provided by the American Rescue Plan supplemental appropriation.

QUANTITATIVE DATA TABLE

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

Research and Development Special Analysis

(Dollars in Millions)

			Disaster Relief Supplemental				
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	RI Damage Mitigation	FY 2023 Total	FY 2024 Request
Investment Activities							
Conduct of Research and Development							
Basic Research	-	-	-	-	-	-	-
Applied Research	-	-	-	-	-	-	-
Subtotal, Conduct of R&D	-	-	-	-	-	-	-
Physical Assets							
Research and Development Facilities	120.60	187.23	-	-	-	187.23	304.67
Research and Development Major Equipment	-	-	-	-	-	-	-
Subtotal, R&D Facilities & Major Equipment	120.60	187.23	-	-	-	187.23	304.67
Total, Research and Development	120.60	187.23	-	-	-	187.23	304.67
Conduct of Education and Training	-	-	-	-	-	-	-
Non-Investment Activities	-	-	-	-	-	-	-
TOTAL	**$120.60**	**$187.23**	**-**	**-**	**-**	**$187.23**	**$304.67**

[1]Excludes $46.53 million provided by the American Rescue Plan supplemental appropriation and $23.45 million provided by the "Extending Government Funding and Delivering Emergency Assistance Act", for necessary expenses related to RCRV construction impacted by Hurricane Ida.

QUANTITATIVE DATA TABLE
AGENCY OPERATIONS AND AWARD MANAGEMENT
Research and Development Special Analysis

(Dollars in Millions)

			Disaster Relief Supplemental				
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS and Science	RI Damage Mitigation	FY 2023 Total	FY 2024 Request
Investment Activities							
Conduct of Research and Development							
Basic Research	-	-	-	-	-	-	-
Applied Research	-	-	-	-	-	-	-
Subtotal, Conduct of R&D	-	-	-	-	-	-	-
Physical Assets							
Research and Development Facilities	-	-	-	-	-	-	-
Research and Development Major Equipment	-	-	-	-	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-	-	-	-	-
Total, Research and Development	-	-	-	-	-	-	-
Conduct of Education and Training	-	-	-	-	-	-	-
Non-Investment Activities	420.21	463.00	-	-	-	463.00	503.87
TOTAL	**$420.21**	**$463.00**	**-**	**-**	**-**	**$463.00**	**$503.87**

QUANTITATIVE DATA TABLE

OFFICE OF INSPECTOR GENERAL

Research and Development Special Analysis

(Dollars in Millions)

			Disaster Relief Supplemental				
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS and Science	RI Damage Mitigation	FY 2023 Total	FY 2024 Request
Investment Activities							
Conduct of Research and Development							
Basic Research	-	-	-	-	-	-	-
Applied Research	-	-	-	-	-	-	-
Subtotal, Conduct of R&D	-	-	-	-	-	-	-
Physical Assets							
Research and Development Facilities	-	-	-	-	-	-	-
Research and Development Major Equipment	-	-	-	-	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-	-	-	-	-
Total, Research and Development	-	-	-	-	-	-	-
Conduct of Education and Training	-	-	-	-	-	-	-
Non-Investment Activities	18.89	23.39	-	-	-	23.39	26.81
TOTAL	**$18.89**	**$23.39**	**-**	**-**	**-**	**$23.39**	**$26.81**

QUANTITATIVE DATA TABLE

OFFICE OF THE NATIONAL SCIENCE BOARD

Research and Development Special Analysis

(Dollars in Millions)

			Disaster Relief Supplemental				
	FY 2022 Actual	FY 2023 Estimate Base	Base	CHIPS and Science	RI Damage Mitigation	FY 2023 Total	FY 2024 Request
Investment Activities							
Conduct of Research and Development							
Basic Research	-	-	-	-	-	-	-
Applied Research	-	-	-	-	-	-	-
Subtotal, Conduct of R&D	-	-	-	-	-	-	-
Physical Assets							
Research and Development Facilities	-	-	-	-	-	-	-
Research and Development Major Equipment	-	-	-	-	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-	-	-	-	-
Total, Research and Development	-	-	-	-	-	-	-
Conduct of Education and Training	-	-	-	-	-	-	-
Non-Investment Activities	4.52	5.09	-	-	-	5.09	5.25
TOTAL	**$4.52**	**$5.09**	**-**	**-**	**-**	**$5.09**	**$5.25**

QUANTITATIVE DATA TABLE

Creating Helpful Incentives to Produce Semiconductors (CHIPS) for American Workforce and Education

Research and Development Special Analysis

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental: Base	Disaster Relief Supplemental: CHIPS and Science	Disaster Relief Supplemental: RI Damage Mitigation	FY 2023 Total	FY 2024 Request
Investment Activities							
Conduct of Research and Development							
Basic Research	-	$12.00	-	-	-	$12.00	$12.00
Applied Research	-	6.00	-	-	-	6.00	5.00
Subtotal, Conduct of R&D	-	18.00	-	-	-	18.00	17.00
Physical Assets							
Research and Development Facilities	-	-	-	-	-	-	-
Research and Development Major Equipment	-	-	-	-	-	-	-
Subtotal, R&D Facilities & Major Equipment	-	-	-	-	-	-	-
Total, Research and Development	-	18.00	-	-	-	18.00	17.00
Conduct of Education and Training	-	7.00	-	-	-	7.00	8.00
Non-Investment Activities	-	-	-	-	-	-	-
TOTAL	**-**	**$25.00**	**-**	**-**	**-**	**$25.00**	**$25.00**