Tools

In pursuit of its mission to provide a widely accessible, state-of-the-art science and engineering infrastructure, NSF invests in Tools. NSF provides support for large, multi-user facilities which provide access to state-of-the-art research facilities essential to the progress of research. Support for these unique national facilities is necessary to advance U.S. research capabilities required for world-class research. NSF also invests in Internet-based and distributed user facilities, advanced computer resources, research networks, major research instrumentation, research resources, digital libraries, and large databases, all of which contribute toward a state-of-the-art science and engineering infrastructure resource. Facilities and resources supported include:

(Millions of Dollars)

	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate
Academic Research Fleet	42	47	54
Advanced Networking Infrastructure	42	44	45
National SMETE Digital Library	1	15	27
Gemini Observatories	7	8	9
Incorporated Research Institutions for Seismology	11	13	13
Laser Interferometer Gravitational Wave Observatory	21	21	19
Major Research Equipment	57	94	139
Major Research Instrumentation	50	50	50
National Astronomy Centers	70	71	71
National Center for Atmospheric Research	72	70	77
Ocean Drilling Program Facilities	31	30	30
Partnerships for Advanced Computational Infrastructure	69	71	71
Polar Science, Operations and Logistics	179	186	202
Research Resources	100	104	118
Other Tools[1]	111	111	121
Total, Tools[2]	$865	$934	$1,045

[1] Includes physics, materials research, ocean sciences, atmospheric sciences, and earth sciences facilities, CESR, the National High Field Mass Spectrometry Center, the MSU Cyclotron, the National High Magnetic Field Laboratory (NHMFL), the Science and Technology Policy Institute, Science Resource Studies, and the National Nanofabrication Users Network.

[2] Totals may not add due to rounding.

The FY 2001 Request for tools such as facilities and research resources totals $1,045 million, about a $111 million increase over FY 2000. Operations and maintenance of multi-user facilities and research resources are funded through the Research and Related Activities (R&RA) and the Education and Human Resources (EHR) accounts; major construction projects are funded through the Major Research Equipment (MRE) account.

In FY 2001, funding for projects within the MRE account will include: $17.44 million to initiate construction of EarthScope; $16.4 million to continue construction of detectors for the Large Hadron Collider; $6.0 million for additional research and development of the Millimeter Array; $12.0 million to initiate construction of the National Ecological Observatory Network (NEON); $28.2 million to continue construction of the Network for Earthquake Engineering Simulation (NEES); $13.5 million to continue the modernization of South Pole Station; and $45.0 million for Terascale Computing Systems. Additional information regarding these projects can be found in the Major Research Equipment section.

Academic Research Fleet

The Academic Research Fleet includes ships, submersibles and large shipboard equipment necessary to support NSF-funded research and the training of oceanographers. Twenty-eight ships are included in the U.S. academic fleet, operated on behalf of the research community, primarily through NSF funding. Large ships are used for distant-water, expeditionary projects such as global change research; intermediate-sized ships support individual investigator research; and smaller regional ships are available for local and coastal research. Special purpose ships are used for submersible and remotely operated vehicle studies. NSF's FY 2001 support for the Academic Research Fleet totals $53.60 million, a $7.0 million or 15 percent increase over FY 2000 to support resources necessary for research in fields related to biocomplexity.

Advanced Networking Infrastructure (ANI)

ANI activities enable and expand scholarly communication and collaboration by providing network access for researchers and educators to high performance, remote scientific facilities including supercomputer facilities and information resources. The very high performance Backbone Network Service (vBNS), together with the high performance connections program, has led to the development of a new level of networking for the nation's research universities. ANI participates in the interagency Next Generation Internet activity to complement the university-led Internet 2 effort jointly supported by the participating universities and the private sector. In the Next Generation Internet initiative, ANI focuses on advanced, high performance network connectivity between research institutions and contributes to the basic infrastructure for high-end research applications. NSF's FY 2001 support for ANI facilities is about $45.40 million, an increase of $1.5 million, or 3.4 percent, over FY 2000.

Gemini Observatories

The two Gemini Telescopes will offer world class capabilities and unique opportunities to the scientific community. In particular, these telescopes are optimized for operation in the infrared region of the telescope and will be able to use adaptive optics, which will provide a resolving power almost twice that of the Hubble Space Telescope. The northern telescope, located on Mauna Kea in Hawaii, achieved first light in December 1998 and is expected to be ready for operational handover in June 2000. First light at the southern observatory at Cerro Pachon, Chile is expected in FY 2000. Normal science operations at the Hawaii site are expected to commence in June 2000 and at the Chilean site in FY 2001. Emphasis in FY 2001 will be on increased support for operations at the two sites. The FY 2001 Budget Request includes $8.65 million for the Gemini Observatories, $600,000 or 7.5 percent over FY 2000.

Incorporated Research Institutions for Seismology (IRIS)

IRIS was created in 1986 to install a global network of seismometers, provide portable seismometers for regional studies, and establish a data management system to provide on-line, distributed access to data on global seismic activity. The IRIS facility serves the needs of the national and international seismology community by making available seismic sensors and data acquisition systems. In addition, the Global Seismic Network operated by IRIS is a backup system for test ban treaty monitoring. NSF's FY 2001 support for IRIS totals about $12.80 million, $200,000 or 1.6 percent over FY 2000.

Laser Interferometer Gravitational-Wave Observatory (LIGO)

The LIGO construction project began in FY 1992 as a collaboration between physicists and engineers at the California Institute of Technology and the Massachusetts Institute of Technology to test the dynamical features of Einstein's theory of gravitation and to study the properties of intense gravitational fields from their radiation. Today, several other institutions are also involved. LIGO consists of identical, but widely separated detectors, one in Hanford, Washington, and the other in Livingston, Louisiana, that will be used for fundamental physics experiments to directly detect gravitational waves and gather data on their sources. In FY 2001, $19.10 million is requested, in accordance with the funding schedule, for LIGO operations funding as it continues its projected three-year instrumentation commissioning phase.

Major Research Equipment (MRE)

A total of $139 million is requested through the MRE account for the following projects:

	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate
Earthscope	--	--	17
HIAPER	--	9	--
Large Hadron Collider	22	16	16
Millimeter Array	9	8	6
National Ecological Observatory Network	--	--	12
Network for Earthquake Engineering Simulation	--	8	28
Polar Aircraft Modernization (LC-130s)	20	12	--
South Pole Station	6	5	14
Terascale Computing Systems	--	36	45
Total, Major Research Equipment Account[1]	$57	$94	$139

[1] Totals may not add due to rounding.

The current and proposed projects within the MRE account are briefly described below. Additional information can be found in the MRE section.

- EarthScope: USArray and SAFOD: a distributed, multi-purpose geophysical instrument array that will make major advances in our knowledge and understanding of the structure and dynamics of the North American continent.

- Large Hadron Collider (LHC): planned to be the world's highest energy accelerator facility. NSF participation includes contributing to the construction of two high energy particle detectors, ATLAS (A Toroidal Large Angle Spectrometer) and CMS (the Compact Muon Solenoid).

- Millimeter Array (MMA): the design and development phase of a planned aperture-synthesis radio telescope operating in the wavelength range from 3 to 0.4 mm.

- National Ecological Observatory Network (NEON): will establish 10 observatories nationwide that will serve as national research platforms for integrated, cutting edge research in field biology.

- Network for Earthquake Engineering Simulation (NEES): will upgrade, modernize, expand and network major facilities including shake tables used for earthquake simulations, large reaction walls for pseudo-dynamic testing, centrifuges for testing soils under earthquake loading, and field testing facilities.

- South Pole Station: Amundsen-Scott South Pole Station, completed in 1975, has code and safety deficiencies that left uncorrected will pose risks to personnel and negatively impact operations. This project was initiated in FY 1998 and is scheduled to be completed by FY 2005.

- Terascale Computing Systems: will provide access to scalable, balanced, terascale computing resources for the broad-based academic science and engineering community served by NSF.

Major Research Instrumentation (MRI)

The Major Research Instrumentation Program (MRI) is designed to improve the condition of scientific and engineering equipment for research and research training in our nation's academic institutions. This program seeks to improve the quality and expand the scope of research and research training in science and engineering, and to foster the integration of research and education by providing instrumentation for research-intensive learning environments. In FY 2001, NSF requests $50.0 million for this ongoing program to support the acquisition and development of research instrumentation for academic institutions.

National Astronomy Centers

There are three National Astronomy Centers, which receive approximately 93 percent of their funding from NSF. The FY 2001 Request includes approximately $71.0 million to support the National Astronomy Centers:

The main facility of the National Astronomy and Ionosphere Center (NAIC) is the 305-meter-diameter radio and radar telescope located at Arecibo, Puerto Rico. NAIC is a visitor-oriented national research center devoted to scientific investigations in radio and radar astronomy and atmospheric sciences. NAIC provides telescope users with a wide range of research and observing instrumentation, including receivers, transmitters, movable line feeds, and digital data acquisition and processing equipment. A major upgrade to the radio telescope and radar was recently completed. The FY 2001 Request includes $9.04 million for NAIC, level with FY 2000, and emphasis will be on extending the high frequency capabilities of the upgraded telescope.

The National Optical Astronomy Observatories (NOAO) is the national center for research in ground-based optical and infrared astronomy. NOAO includes Kitt Peak National Observatory, outside Tucson, Arizona; Cerro Tololo Inter-American Observatory, in Chile; and the National Solar Observatory, in Arizona and New Mexico. Large optical telescopes, observing equipment, and research support services

are made available to qualified scientists. In FY 2001, the Global Oscillation Network Group (GONG) at NOAO will continue monitoring small-scale oscillations of the sun, permitting studies of the sun's interior structure. The instrumentation for the Synoptic Optical Long-term Investigation of the Sun (SOLIS), will begin refined studies of the Sun's atmosphere and surface, including determining conditions which give rise to solar flares. The FY 2001 Request includes $29.69 million for NOAO, level with FY 2000.

The National Radio Astronomy Observatory (NRAO) is headquartered at Charlottesville, Virginia, and operates radio telescopes at sites in Arizona, New Mexico, and West Virginia. NRAO makes radio astronomy facilities available to qualified visiting scientists and provides staff support for use of the large radio antennas, receivers, and other equipment needed to detect, measure, and identify radio waves from astronomical objects. In FY 2001, the Green Bank Telescope will transition from commissioning to operations. The FY 2001 Request includes $32.53 million for NRAO, level with FY 2000.

National Center for Atmospheric Research (NCAR)

NCAR facilities serve the entire atmospheric sciences research community and part of the ocean sciences community. Facilities available to university, NCAR, and other researchers include an advanced computational center providing resources and services well suited for the development and execution of large models and for the archiving and manipulation of large data sets. NCAR also provides research aircraft which can be equipped with sensors to measure dynamic, physical, and chemical states of the atmosphere. In addition, one airborne and one portable ground-based radar and other surface sensing systems are available for atmospheric research. Roughly 25 percent of the funding for NCAR facilities is provided by non-NSF sources. In FY 2000, more than 1,500 researchers and students will use the facilities, and approximately 150 visiting scientists will stay for extended periods. NSF's FY 2001 support for NCAR totals approximately $77.02 million, an increase of about $6.90 million, or 9.8 percent over FY 2000. This increase will enhance usability of high-end computer systems and research activities related to Earth's natural cycles.

National SMETE Digital Library

A National SMETE Digital Library (NSDL) responds to needs articulated by the NSF, the academic community, and corporate leaders for accelerating much needed improvements in science, mathematics, engineering, and technology education (SMETE). The NSDL, capitalizing on recent developments in digital libraries, will provide: a forum for the merit review and recognition of quality educational resources; a mechanism for electronic dissemination of information about high-quality educational materials, pedagogical practices, and implementation strategies; a centralized registry and archive for educational resources; and a resource for research in teaching and learning. In addition, the NSDL will provide an infrastructure to support and accelerate the impact of NSF programs. For example, developers of curricula and courses will benefit from awareness and knowledge of extant instructional materials, as well as information on their implementation. NSF support for the NSDL will total $27.0 million, an increase of $12.0 million or 80 percent over FY 2000.

Ocean Drilling Program Facilities

The Ocean Drilling Program is a multinational program of basic scientific research in the oceans which uses drilling and data from drill holes to improve fundamental understanding of the role of physical, chemical, and biological processes in the geological history, structure, and evolution of the oceanic portion of the Earth's crust. Operational support for this activity is shared by six international partners, comprising 18 countries. NSF's FY 2001 support for Ocean Drilling Program facilities totals $30.10 million, level with FY 2000.

Partnerships for Advanced Computational Infrastructure (PACI)

Partnerships for Advanced Computational Infrastructure provides access to, and support for, high-end computing for the national scientific and engineering community, and the development and application of the necessary software, tools and algorithms for their use on scalable, widely distributed resources. The $70.83 million requested in FY 2001 will permit the PACI network, now in its third year, to enter the era of terascale computing. In FY 2001, emphasis will be on scaling applications codes to be ready for transitions to the Terascale Computing Systems and access and visualization techniques for very large data resources to support research in disciplinary areas. The education, outreach and training component of PACI will continue to broaden and accelerate the capability of the nation to utilize the advanced computational capabilities being developed.

Polar Science Operations and Logistics

Polar facilities make research possible in the remote and hazardous Antarctic continent, where all infrastructure must be provided. In accord with U.S. Antarctic policy, three year-round Antarctic research stations are operated and maintained — McMurdo Station on Ross Island, Palmer Station on Anvers Island, and Amundsen-Scott South Pole Station. In addition, necessary facilities include ski-equipped and fixed-wing aircraft, helicopters, research vessels (including a specially constructed ice-breaking research vessel), and an ice-strengthened supply and support ship. Logistical support for polar facilities is supplied in part by the Department of Defense. Over 650 researchers and students utilize the Antarctic facilities each year.

Arctic facilities include camps and sites for studies of greenhouse gases, monitoring stations for research on ultra-violet radiation, ice coring sites for studies of global climate history, high latitude radar observatories and magnetometers for upper atmospheric research, use of the U.S. Coast Guard Cutter Healy, and the use of a vessel from the academic research fleet for oceanographic research in the Arctic Ocean. NSF's FY 2001 support for Polar Science Operations and Logistics totals $201.53 million, 8.2 percent over FY 2000.

Research Resources

Research Resources supports a range of activities throughout the Research and Related Activities account, including: multi-user instrumentation; the development of instruments with new capabilities, improved resolution or sensitivity; upgrades to field stations and marine laboratories; support of living stock collections; facility-related instrument development and operation; and the support and development of databases and informatics tools and techniques. These various resources provide the essential platforms and tools for effective research in all areas of science and engineering. In FY 2001, funding for Research Resources increases $13.73 million to a total of $118.06 million.

Other Tools

This category includes:

- funding for the final year of a five year-upgrade of the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University;

- continued support for the operation and maintenance of the newly upgraded Cornell Electron Storage Ring (CESR) at Cornell University;

- continued support for the Science and Technology Policy Institute to continue to provide analytical support to the Office of Science and Technology Policy (OSTP) to identify near-term and long-term objectives for research and development and identify options for achieving those objectives;

- continued support for the National High Magnetic Field Laboratory (NHMFL), operated by Florida State University, the University of Florida, and Los Alamos National Laboratory; and

- an increase of $2.0 million for Science Resource Studies to provide policymakers, researchers and other decision makers with high quality data and analysis for making informed decisions about the nation's science, engineering, and technology enterprise.

Other items within this category include the National High Field FT-ICR Mass Spectrometry Center, and physics, materials research, ocean sciences, atmospheric sciences, and earth sciences facilities

FY 2001 Performance Goals for Tools

The following tables summarize NSF's FY 2001 Performance Goals for Tools. For additional information, see the FY 2001 Performance Plan.

Annual Performance Goals For Results – Tools

Outcome Goal	FY 2001-2005 GPRA Strategic Plan	FY 2001 Areas of Emphasis
	NSF is successful when results reported in the period demonstrate sufficient progress in achieving:	
Tools -- Broadly accessible, state-of-the-art information bases and shared resarch and education tools	❖ Shared-use platforms, facilities, instruments, and databases that enable discovery and enhance the productivity and effectiveness of the science and engineering workforce. ❖ Networking and connectivity that takes full advantage of the Internet and makes SMET information available to all ❖ Information and policy analyses that contribute to the effective use of science and engineering resources.	Investments in Major Research Equipment Continue investments in: ◗ Terascale Computing System ◗ Major Research Instrumentation ◗ K-16 SMETE digital library ◗ S&E information/reports/databases ◗ New types of scientific databases & tools for using them
Strategic Outcome Goal	FY 2001 Annual Performance Goal	
Tools -- Data Relevance and Quality	Determine what data are needed to better reflect the 21st century S&T enterprise. Develop, assess, and begin implementation of design options for recasting SRS S&E resources data collections. (New Goal)	
	Determine the aspects of each SRS survey most needing improvement, based upon the standard set of data quality measures for reporting SRS products. Improve the quality of at least one half the core SRS surveys.	

Annual Performance Goals For NSF's Investment Process

Performance Area	**FY 2001 Annual Performance Goal**
Facilities Oversight	
Construction and upgrade	Maintain FY 2000 goal: keep construction and upgrades within annual expenditure plan, not to exceed 110 percent of estimates. FY 1999 result: majority of facilities within 110% of spending estimates.
	Maintain FY 2000 goal: keep construction and upgrades within annual schedule, total time required for major components of the project not to exceed 110 percent of estimates. FY 1999 result: majority of facilities on schedule.
	Maintain FY 2000 goal: for all construction and upgrade projects initiated after 1996, keep total cost within 110 percent of estimates made at the initiation of construction. FY 1999 result: No projects completed in FY 1999.
Operations	Maintain FY 2000 goal: Keep operating time lost due to unscheduled downtime to less than 10 percent of the total scheduled operating time. FY 1999 result: substantial majority of facilities were operating efficiently.

Highlights

Most accurate galaxy distance: Researchers at the National Radio Astronomy Observatory have used the Very Long Baseline Array (VLBA) to make measurements of water emission from the central regions of the galaxy NGC 4258. The measurements yielded a *direct* measurement of the distance to this object, about 23.5 million light-years. This result differs significantly from the inferred distance of about 28 million light years obtained by astronomers using the Hubble Space Telescope. There may be previously-unrecognized systematic errors in the Hubble distance scale for the Universe and this will affect current estimates of the age of the Universe.

New vistas for high magnetic field research: A team of researchers from the National High Magnetic Field Laboratory (NHMFL) has conducted the first experiments in continuous magnetic fields of 45 tesla (one million times the Earth's magnetic field) in a new hybrid magnet, one of the crown jewels of this national user facility. The 45-tesla hybrid magnet consists of two very large magnets. The total magnet system weighs 34 tons and stands 22 feet tall. A huge superconducting magnet forms the outside layer and is the largest magnet of its type ever built and operated to such high field. It is cooled to within a few degrees of absolute zero temperature using a superfluid helium cryogenic system. A large resistive magnet (electromagnet) sits in the center of the superconducting magnet, and the two magnets work in tandem to provide the most intense constant magnetic field on Earth. This new magnetic field strength gives scientists a new scale of magnetic energy to create new states of matter and probe deeper into electronic and magnetic materials than ever before.

CESR Continues World-Class Performance: The Cornell Electron-positron Storage Ring achieved a new high for colliding beam luminosity and brought scientists a step closer to understanding the matter-antimatter asymmetry in the universe as well as a fundamental asymmetry of nature called CP violation. Both CESR and its associated particle detector CLEO were upgraded to achieve new levels of sensitivity for study of rare B-meson decays thought to be central to understanding CP violation. CESR achieved a record peak luminosity in February 1999 – 8 times the previous CESR design value – through a combination of innovations in accelerator physics and technology pioneered at Cornell. CLEO reported the first observation of an elusive decay mode that was once thought to be a channel to access a full description of CP violation. The weakness of this decay will now force us to devise a new strategy. Measurements of radiative decay of the b quark to the s quark (first reported several years ago) have improved greatly in accuracy thanks to CESR advances. The results agree well with the Standard Model predictions and now place tight restrictions on the range of possible effects beyond the Standard Model.

South Pole Station Modernization: SPSM is currently on schedule and within budget. The acceleration of funding has made it possible to move up procurement of materials and construction of the Dark Sector Lab, a 3000 square foot building which will support astrophysics research. The accelerated funding has made it possible to combine previously separate procurements for major components – structural steel, wall panels, and other construction materials - into several large purchases instead of a greater number of smaller purchases. In addition to providing for consistency of materials for the station (simplifying long-term maintenance), this approach will likely result in saving labor costs (for procurement) and inflation. Also, perhaps most importantly, the acceleration helps guard against possible procurement-associated delays in the future, and thus against schedule-driven cost increases.

South Pole Airdrop: On July 11, 1999 - essentially the middle of the Antarctic winter - the Air Force conducted a mission to airdrop medical supplies and equipment at Amundsen-Scott South Pole Station to assist in the treatment of the station doctor who discovered a lump in one of her breasts. Station personnel braved extreme cold to safely retrieve the bundles. All critical medical supplies and most of the electronic equipment, including microscopes, cameras, and equipment to improve communications,

survived the drop. These allowed the patient, in consultation with medical experts in the United States, to begin an appropriate course of treatment.

Supercomputing Excellence: The NSF Supercomputer Centers Program, and its PACI successor, have led the way in adding computational modeling to theory and experiment as means for developing scientific understanding. These centers have changed the way scientific phenomena are analyzed, modeled and visualized. A striking example of the importance of advanced computation in basic scientific research was recognized in 1998 with the award of the Nobel Prize for Chemistry to John Pople and Walter Kohn for laying the foundations to a new approach to research in chemistry. This approach is in the same mode as the *ab initio* computations performed on the CRAY T90 at the San Diego Supercomputer Center (SDSC).

The Search for Extra-Solar Planets: A long-standing aim of National Center for Atmospheric Research's High Altitude Observatory (HAO) astrophysics program has been to detect and characterize Sun-like pulsations in distant stars. The technology required to make such studies involves extremely precise measurements of the line-of-sight velocity or brightness of the target stars. It turns out that these measurements are precisely those needed to detect planets circling other stars. A researcher has recently exploited these techniques to identify new, extra-solar planets. An exciting result of this effort was the discovery in April that the star Upsilon Andromedae is orbited by three planets, all with masses comparable to that of Jupiter, located at distances from their star that range from .05 to 2.5 astronomical units. This discovery was the result of a collaboration involving scientists from NCAR, the Harvard-Smithsonian Center for Astrophysics, and San Francisco State University, using the Anglo-Australian Telescope. It is the first detection of a multiple-planet solar system outside our own, and has been widely interpreted as evidence that solar systems like ours may be fairly common companions to Sun-like stars.