13. GENERAL SCIENCE, SPACE, AND TECHNOLOGY

Table 13–1. Federal Resources in Support of General Science, Space, and Technology
(In millions of dollars)

Function 250	1999 Actual	Estimate					
		2000	2001	2002	2003	2004	2005
Spending:							
Discretionary Budget Authority ...	18,793	19,192	20,761	21,179	21,471	22,094	22,495
Mandatory Outlays:							
Existing law	42	102	66	34	34	34	34
Tax Expenditures:							
Existing law	3,595	2,875	5,245	5,675	5,060	4,850	3,915

Science and technology are principal agents of change and progress, with over half of the Nation's economic productivity growth in the last 50 years attributable to technological innovation and the science that supported it. Appropriately enough, the private sector makes many investments in technology development. The Federal Government, however, also plays a role—particularly when risks are too great or the potential return for companies is too long-term.

Within this function, the Federal Government supports areas of cutting-edge science, through the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Department of Energy (DOE). The activities of these agencies contribute to greater understanding of the world in which we live, ranging from the edges of the universe to the smallest imaginable particles, and to new knowledge that may or may not have immediate applications to improving our lives. Because the results of basic research are unpredictable, developing performance goals for this area presents unique challenges.

Each of these agencies funds high-quality research and contributes to the Nation's cadre of skilled scientists and engineers. To continue this tradition, and as a general goal for activities under this function, at least 80 percent of the research projects will be reviewed by appropriate peers and selected through a merit-based competitive process. In 1999, 94 percent of the project funds awarded through grants by NSF, 82 percent by NASA, and 91 percent by DOE were reviewed by appropriate peers and selected through a merit-based competitive process. Because these percentages are based on data that do not reflect the entire research activity at all agencies, the Administration will need to reform the definitions in next year's report.

Another important Federal role is to construct and operate major scientific facilities and capital assets for multiple users. These include telescopes, satellites, oceanographic ships, and particle accelerators. Many of today's fast-paced advances in medicine and other fields rely on these facilities. As general goals, agencies will keep the development and upgrade of these facilities on schedule and within budget, not to exceed 110 percent of estimates. In 1999, NASA development and upgrades were within 113 percent of cost estimates and 108 percent of schedule estimates, and those within DOE were within 100 percent of cost and schedule estimates. In operating the facilities, agencies will keep the operating time lost due to unscheduled

downtime to less than 10 percent of the total scheduled possible operating time, on average. In 1999, NASA developed a baseline for loss of scheduled operating time due to scheduled downtime of 5.6 percent to enable them to report next year on unscheduled downtime. DOE user facilities kept unscheduled downtime to nine percent. NSF is in the process of developing a database, and will report in next year's budget.

One of the specific areas in which the Federal Government has invested is the Internet, which has changed the lives of millions of Americans. Previous Federal investments helped to establish the Internet, and current investments are making the Internet faster and available to more Americans. Since 1998, the Federal Government has invested in the Next Generation Internet Initiative, which focuses on a variety of ways to improve the operation of the network. For example, it is focusing on how to make the Internet operate at speeds 100 to 1,000 times faster than the current Internet to allow a typical user to view routinely highly-detailed pictures and to explore complex data bases. In 1999, the testbed connected over 100 sites to a network that will deliver speeds 100 times faster than the 1998 Internet, and over 10 sites to a second network that will deliver speeds 1,000 times faster. This initiative is also examining ways to ensure that information transferred over the Internet is used only by the intended user for its intended purpose, and to make the Internet as reliable as local telephone service while greatly reducing the effort required to administer and manage the network.

The budget proposes $20.76 billion to conduct activities in support of general science, space, and technology. The Government also stimulates private investment in these activities through over $5 billion a year in tax credits and other preferences for research and development (R&D).

National Aeronautics and Space Administration

The budget proposes $13.1 billion for NASA activities in this function. NASA serves as the lead Federal agency for research and development in civil space activities, working to expand frontiers in air and space to serve America and improve the quality of life on Earth. NASA pursues this vision through balanced investment in four enterprises—Space Science, Earth Science, Space Transportation Technology, Human Exploration and Development of Space—and mission support to carry out these activities.

NASA's achievements in 1999 included direct and independent confirmation of the existence of extrasolar planets; production of a global, three-dimensional map of Mars; successful launch and operation of the Chandra X-ray Observatory, which is now returning unprecedented images of never-before-seen objects beyond our galaxy; improvement in measuring global rainfall from an uncertainty of 50 percent to 25 percent; and, the first successful docking of the Space Shuttle to the International Space Station.

Space Science programs, for which the budget proposes $2.4 billion, are designed to enhance our understanding of how the universe was created, what fundamental rules govern its evolution, how stars and planets evolve and die, how space phenomena affect Earth, and the possible existence of life beyond Earth. In 1999, NASA developed and launched seven spacecraft with an average 3.8 percent cost overrun, although two Mars missions failed to return data. The NASA Advisory Council indicated that eight of the eight NASA performance plan objectives for Space Science have been successfully met. In 2001,

- NASA will successfully launch at least four of its six planned spacecraft—the Mars Surveyor—01 Orbiter, the Genesis mission, the Galaxy Evolution Explorer, the Microwave Anisotropy Probe, Cooperative Astrophysics and Technology Satellite, and Gravity Probe B—within 10 percent of their schedules and budgets. For those spacecraft already successfully launched, NASA Space Science will meet expected operations performance for at least 80 percent of its operating missions;
- NASA's Advisory Council will rate the Space Science performance plan objectives as being successfully met. Examples of objectives include: investigate the composition, evolution and resources of Mars, the

Moon, and small solar system bodies such as asteroids and comets; identify planets around other stars; and observe the evolution of galaxies and the intergalactic medium; and,

- NASA will continue and expand the integration of education and enhanced public understanding within its research and flight mission programs. Space Science funded education and outreach activities will be in planning or implementation in at least 34 States.

Earth Science programs, for which the budget proposes $1.4 billion, focus on the effects of natural and human-induced changes on the global environment through long-term, space-based observation of Earth's land, oceans, and atmospheric processes. In 1999, NASA launched two spacecraft, Landsat–7, and the Quick Scatterometer. Users have routinely received earth science data products within five days of receipt or production of the requested data product. The NASA Advisory Council indicated that 29 of 35 performance targets were successfully met. In 2001,

- NASA will successfully launch and operate at least two of three planned spacecraft—Aqua, IceSat, and Triana—within 10 percent of their schedules and budgets;
- NASA will increase by 20 percent the volume of climate data it archives over the 2000 target of 368 terabytes, increase the number of products delivered from its archives by 10 percent over 2000, and make the data available to users within five days; and,
- NASA's Advisory Council will rate all near-term Earth Science objectives as being met or on schedule. Examples of objectives include: observe and document land cover and land use change and impacts on sustained resource productivity; and understand the causes and impacts of long-term climate variations on global and regional scales.

Aero-Space Technology programs, for which the budget proposes $616 million, work with the private sector to develop and test experimental launch vehicles that reduce the cost of access to space. In 1999, the X–33 program began testing of the liquid hydrogen tank and the aerospike engine resulting in a decision to redesign the tank. The X–34 program initiated hotfire testing of the Fastrac engine and completed delivery roll out and systems verification review of the first flight vehicle. In 2001,

- the X–34 program will complete assembly of the third experimental test vehicle; and,
- the X–37 program will commence vehicle assembly.

Human Exploration and Development of Space programs, for which the budget proposes $5.5 billion, focus on the use of human skills and expertise in space. In 1999, the space shuttle achieved a 60 percent increase in predicted reliability over the 1995 levels, observed an average of 4.75 anomalies per flight, achieved an on-time launch rate of 67 percent, and achieved a 12-month flight preparation cycle. The International Space Station program delivered the first two elements of the orbiting laboratory to space, and conducted successful operations throughout the year. In 2001,

- NASA will successfully complete no less than 85 percent of planned operations schedules and milestones for 2001 for the International Space Station. For example, NASA will conduct permanent on-orbit operations with an estimated 8,000 crew hours dedicated to assembly, vehicle operations, and payload operations; and
- NASA will ensure that Space Shuttle safety, reliability, availability and cost will improve, by achieving seven or fewer flight anomalies per mission, successful on-time launches 85 percent of the time, and a 12-month manifest preparation time. NASA will complete the checkout launch and control system application for the Orbiter Processing Facility.

National Science Foundation

The budget proposes $4.5 billion in 2001 for NSF in this function. While NSF represents just three percent of Federal R&D spending, it supports nearly half of the non-medical basic research conducted at academic institutions, and 30 percent of Federal support for mathematics and science edu-

cation. In 1999, NSF-funded scientists uncovered the structural basis that explains a virus' ability to force host cells to manufacture the virus' own proteins. This is important for understanding retroviruses, which are responsible for causing many cancers in vertebrates. In addition, the May 3, 1999, tornado outbreak in Central Oklahoma was used to test a regional forecast system developed at an NSF-funded center. The storm-scale forecast showed improved predictive ability and increased precision. As this forecasting capability is further developed, it will become a critical tool in determining which areas will be most severely hit by storms, allowing sufficient and timely warnings to be issued to persons in affected areas.

NSF research and education investments are made in three primary areas:

Ideas: Approximately one-half of NSF's resources support research projects performed by individuals, small groups, and centers. In 2001,

- an independent panel will judge whether research results in the period demonstrate sufficient progress toward achieving a robust and growing fundamental knowledge base; important discoveries; partnerships connecting discovery to innovation, learning and societal advancement; and research and education processes that are synergistically coupled; and,
- NSF will maintain the 2000 goal of having a minimum of 30 percent of competitive research grants go to new investigators. In 1999, 27 percent of competitive research grants went to new investigators.

Tools: NSF investments provide state-of-the art tools for research and education, such as instrumentation and equipment, multi-user facilities, accelerators, telescopes, research vessels and aircraft, and earthquake simulators. In addition, resources support large databases as well as computation and computing infrastructures for all fields of science, engineering, and education. Nearly a quarter of NSF's budget provides the tools required for cutting-edge research. In 2001,

- NSF facilities will continue to meet the function-wide goals to remain within cost and schedule, and to operate efficiently.

People: Activities to facilitate development of a diverse and talented work force of scientists, engineers, and well-prepared citizens account for about 25 percent of NSF's budget. NSF supports formal and informal science, mathematics, engineering, and technology education at all levels, including multidisciplinary education and training for graduate students. In addition, resources support projects to develop curriculum, enhance teacher training and professional development, and provide educational opportunities for students from pre-K through postdoctoral. In 1999, 40 NSF-sponsored projects implemented mathematics and science standards-based curricula in over 81 percent of participating schools, and provided professional development for more than 156,000 teachers. All participating educational systems demonstrated some level of improvement in student achievement in mathematics and science on a battery of system-selected assessment instruments. Moreover, in 1999, systemic initiatives and related teacher enhancement programs provided intensive professional development to a total of 82,400 teachers, exceeding the goal of 65,000. For 2001, NSF will continue to adhere to the following goal:

- Over 80 percent of schools participating in a systemic initiative program will: 1) implement a standards-based curriculum in science and mathematics; 2) further professional development of the instructional work force; and, 3) improve student achievement on a selected battery of tests, after three years of NSF support.

Department of Energy

The budget proposes $3.2 billion in 2001 for DOE science programs and supporting activities. DOE operates major scientific facilities including particle accelerators, magnetic plasma confinement reactors for fusion research, synchrotron light sources, neutron sources, supercomputers, and high-speed networks that researchers use in fields ranging from the physical and materials sciences to the biomedical and life sciences. These facilities are available, on a competitive basis,

to scientists and engineers in universities, industry and other Federal agencies.

In 1999, an international team of nuclear scientists at DOE's Lawrence Berkeley National Laboratory added three new elements to the periodic table. Elements 116 and 118 are the heaviest yet created and confirm physicists' long-standing prediction of an "island" within the Periodic Table of the elements where heavier nuclei become increasingly stable. In addition, DOE-funded university researchers have developed a new class of organic magnets that are stable in air. For some of these materials, their magnetism can be switched on or off using light, a process found only in molecular or polymer-based magnets. The potential applications of these new materials are only beginning to be explored.

The budget proposes $1.02 billion for Basic Energy Sciences (BES), which supports basic research in the materials, chemical and engineering sciences, geosciences, and plant and microbial biosciences. As part of its mission, BES plans, constructs, and operates major scientific user facilities. In 1999, DOE redesigned the Spallation Neutron Source to have a more defensible cost and schedule baseline. In 2001,

- DOE will meet the cost and schedule milestones for upgrade and construction of scientific user facilities, including the construction of the Spallation Neutron Source, as confirmed by regular external independent reviews.

The budget proposes $182 million for Advanced Scientific Computing Research, which supports applied mathematics, computer science, and networking research and operates supercomputer, networking and related facilities to enable the analysis, simulation, and prediction of complex physical phenomena. In 1999, DOE-funded computer scientists developed a technique that reduces the time it takes to process a three-dimensional x-ray image from overnight to less than 20 minutes. This advance will greatly improve the productivity of the Nation's synchrotron light sources. By the end of 2001,

- the National Energy Research Scientific Computing Center will deliver 3.6 Teraflop capability to support DOE's science mission.

The budget proposes $445 million for Biological and Environmental Research (BER), which supports basic research to identify, understand, and anticipate the long-term health and environmental consequences of energy production, development, and use. In 1999, BER-funded scientists determined the complete gene sequence of three microbes: the radiation-resistant *Deinococcus radiodurans,* the pollutant-eating *Shewanella putrefaciens,* and the carbon-fixing *Chlorobium tepidum*. In 2001,

- DOE, through its Joint Genome Institute, will meet its commitment to sequence three of the 24 human chromosomes as part of an international effort to sequence the entire human genome. DOE will sequence and submit to public databases at least 10 percent of the human genome with an accuracy of 99.9 percent.

The budget proposes $1.08 billion for High Energy and Nuclear Physics, which strives to understand the nature of matter and energy in terms of the most elementary particles and forces and to more completely explain the structure and interactions of atomic nuclei. In the third quarter of 1999, construction of the Relativistic Heavy Ion Collider was completed on schedule and within budget. In 2001,

- DOE will make progress in achieving luminosity and operational efficiency goals for the B-factory at the Stanford Linear Accelerator Center, and begin Fermilab's Tevatron Extended Run II, which has the potential to discover a new class of elementary particles.

The budget proposes $247 million for DOE's Office of Fusion Energy Sciences, which conducts research to advance plasma science, fusion science, and fusion technology. In 2001,

- DOE will deliver the first physics results from the radio-frequency driven Electric Tokamak.

Tax Incentives

Along with direct spending on R&D, the Federal Government has sought to stimulate private investment in these activities with tax preferences. The current law provides a 20-percent tax credit for private research and experimentation expenditures above a certain base amount. The credit, which expired in 1999, was retroactively reinstated for five years, to 2004, in the Tax Relief Extension Act of 1999. The credit will cost $3.4 billion in 2001 and $14.2 billion from 2001 to 2005.

A permanent tax provision also lets companies deduct, up front, the costs of certain kinds of research and experimentation, rather than capitalize these costs. This tax expenditure will cost $1.9 billion in 2001. Finally, equipment used for research benefits from relatively rapid cost recovery. The cost of this tax preference is calculated in the tax expenditure estimate for accelerated depreciation of machinery and equipment.