

SPECIAL ANALYSIS K

RESEARCH AND DEVELOPMENT

This analysis covers the funding of research and development across all departments and agencies with R&D programs of \$10 million or more which represents over 99% of total Federal funds for R&D. It consists of two sections. The first highlights the R&D policies and trends in the 1985 budget. The second describes in more detail the R&D programs of 13 agencies whose R&D obligations individually exceed \$150 million.

HIGHLIGHTS

In 1985, total Federal funding for research and development including R&D facilities is estimated at \$53 billion, an increase of \$6 billion or 14 percent above the 1984 estimated level of \$47 billion. The support for the conduct of basic research, included within this total, is estimated to increase by 10 percent, from \$7.2 billion in 1984 to \$7.9 billion in 1985.

The Federal Government supports research and development:

- to meet direct needs of the Federal Government where the principal users of the results of the R&D are the supporting agencies. Examples include R&D for national defense, and research to support environmental regulation; and,
- to assist in meeting broad national needs, particularly where the private sector lacks incentives for adequate investments to assure long-term economic growth and continued improvement in the quality of life. Examples include Federal investments in basic research across all fields of science and in agricultural and health research.

The 1985 budget continues to reflect the high priority that this Administration gives to R&D that is appropriate for Federal support. It provides for:

- increases in high priority R&D programs of the Department of Defense;
- continued growth in Government-wide support of basic research, with particular emphasis in the National Science Foundation budget on programs to strengthen engineering research and training, and in both the Foundation and the Department of Energy on efforts to enhance the productivity of U.S. scientists through better access to advanced computers; and,

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- initiation of several major new projects that will facilitate research advances in a number of scientific fields. These include, for example, in the NSF, a new radiotelescope, the Very Long Baseline Array; in NASA, the Upper Atmosphere Research Satellite; and in the DOE budget, a new accelerator facility for nuclear physics at Newport News, Virginia.

At the same time, the 1985 budget continues to propose reductions in nearer term R&D programs that are not considered an appropriate Federal responsibility and, thus, should be left to the States or the private sector for appropriate investments. These reductions occur in a number of programs and agencies, including nearer term technology development programs of the Department of Energy, selected programs of the Department of Commerce (e.g., fire research in the National Bureau of Standards and research activities of the Department of Interior (e.g., the Mineral Institutes program in the Bureau of Mines).

The Administration will continue in 1985 to seek to use increased research funds more effectively, particularly in the basic sciences by:

- supporting researchers of the highest calibre in science and engineering, particularly those just beginning their academic careers. This effort will help to assure both the present and future availability of a high-quality scientific workforce to meet national needs;
- building on the effort begun in 1984 to provide additional funds to upgrade scientific instrumentation at universities in order to enhance the quality and productivity of academic research and the training of future scientists and engineers; and,
- continuing to encourage creative interaction among scientists in industry, universities and Government in order to bring together the scientific expertise and approaches needed to address the most challenging scientific and technical problems.

Total obligations and outlays for the conduct of all Federal R&D programs and for related facilities are shown in Table K-1.

Table K-1. TOTAL FEDERAL FUNDING FOR CONDUCT OF R&D AND RELATED FACILITIES

(In billions of dollars)

	Obligations			Outlays		
	1983 actual	1984 estimate	1985 estimate	1983 actual	1984 estimate	1985 estimate
Conduct of R&D	38.4	45.3	51.8	36.6	42.7	48.7
R&D facilities	1.1	1.4	1.3	1.1	1.2	1.4
Total	39.6	46.7	53.1	37.6	43.9	50.1

CONDUCT OF RESEARCH AND DEVELOPMENT

The budget for 1985 represents \$52 billion in obligations for the conduct of R&D, an increase of \$7 billion or 14 percent over 1984. Highlights of the proposed programs of the major R&D agencies, accounting for over 90 percent of the obligations for the conduct of R&D by the Federal Government, are presented below.

- **Department of Defense (DOD).**—Obligations for the conduct of R&D by DOD are estimated at \$33.9 billion for 1985, an increase of \$6.3 billion or about 23 percent above 1984. The increased funds are proposed for R&D largely related to advances in strategic and tactical systems and technology development. In addition, DOD will increase its funding of basic research by about 15 percent, with increased emphasis on materials and microelectronics.
- **Department of Energy (DOE).**—Obligations for the conduct of R&D programs in the Department of Energy are estimated at \$4.9 billion, a slight increase over 1984. Within this total, basic research funding would be increased by \$191 million, or more than 18 percent. The proposed R&D funding will be used to strengthen the nuclear weapons R&D program, to continue support of longer term energy research and to enhance support for basic research in high-energy and nuclear physics. The 1985 budget includes initial funds to plan for the construction of an advanced nuclear physics accelerator at a new laboratory in Newport News, Virginia. In addition, it provides for preliminary research and development activities for the design of a possible next-generation high energy particle accelerator. The budget also continues support for previously approved projects such as the Center for Advanced Materials at the Lawrence Berkeley Laboratory and the linear colliding beam accelerator at the Stanford Linear Accelerator Center.
- **Department of Health and Human Services (HHS).**—An increase of more than \$90 million in obligations for the conduct of R&D is proposed for HHS in 1985, from \$4.9 billion to \$5.0 billion. This represents a \$600 million increase, or 14 percent, over the two-year period, 1983–1985. The National Institutes of Health (NIH) accounts for about 88 percent of the total HHS funding for R&D. An increase of \$102 million over 1984 is proposed for the R&D programs of NIH, including research in the basic biomedical sciences.
- **National Aeronautics and Space Administration (NASA).**—Obligations for the conduct of R&D by NASA are estimated at \$3.3 billion in 1985, an increase of \$84 million over 1984. This will allow NASA to pursue a vigorous program of science, applications and long-term advanced technology development

for space projects and future aircraft. The 1985 budget proposes several new initiatives. These include the Mars Geoscience/Climatology Orbiter to map the Martian surface; the Upper Atmosphere Research Satellite, to investigate the chemistry of the Earth's upper atmosphere, and the Scatterometer, an instrument for a joint NASA-Navy mission to better understand global wind patterns. Previously approved projects such as the Numerical Aerodynamic Simulator, the Galileo mission to Jupiter and the Space Telescope will be continued.

- **National Science Foundation (NSF).**—Obligations for research supported by NSF are expected to increase by about \$170 million, or 14 percent—to more than \$1.4 billion in 1985. The budget principally provides increased support of research in academic institutions through project grants with emphasis on the physical sciences and engineering and on improving university research instrumentation. The budget also funds a new program aimed at strengthening research and training in engineering at universities through support of centers for cross-disciplinary research in engineering and enhanced access to supercomputers by academic scientists. In addition, funds are included to initiate the acquisition of an Advanced Vector Computer for the National Center for Atmospheric Research and for construction of the Very Long Baseline Array radiotelescope.

Table K-2 summarizes Federal support for the conduct of R&D by agency.

CONDUCT OF BASIC RESEARCH

The 1985 budget reflects the high priority which this Administration continues to give to the support of basic research across all scientific disciplines. Additional support for basic research is based on the premise that the long-term economic strength of the Nation and continued improvement in the well-being of its citizens requires a sustained investment in basic scientific research. The continued growth of scientific knowledge in fields such as mathematics, physics, chemistry, biology and the various engineering disciplines provide the foundation for the achievement of long-term national objectives of a strong defense, economic security, and an enhanced quality of life. In addition, support for basic research at universities provides the foundation for the education of future scientists and engineers.

Funding for basic research is included within the overall Federal support for the conduct of R&D. In 1985, obligations for the conduct of basic research are estimated at \$7.9 billion, an increase of \$732 million or, more than 10 percent above the level for 1984. This

Table K-2. CONDUCT OF RESEARCH AND DEVELOPMENT BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1983 actual	1984 estimate	1985 estimate	1983 actual	1984 estimate	1985 estimate
Defense-Military functions.....	22,925	27,636	33,852	21,057	25,310	31,053
Energy.....	4,491	4,844	4,885	4,771	4,853	4,744
Health and Human Services.....	4,348	4,859	4,950	4,092	4,529	4,869
(National Institutes of Health).....	(3,788)	(4,240)	(4,342)	(3,538)	(3,968)	(4,267)
National Aeronautics and Space Administration..	2,570	3,257	3,341	2,538	3,462	3,314
National Science Foundation.....	1,062	1,239	1,408	992	1,136	1,362
Agriculture.....	846	872	898	832	866	880
Transportation.....	360	519	498	280	445	481
Interior.....	374	415	363	403	403	368
Commerce.....	327	357	272	324	349	276
Environmental Protection Agency.....	241	250	281	312	252	277
Agency for International Development.....	177	225	264	235	298	297
Veterans Administration.....	164	223	198	154	174	208
Nuclear Regulatory Commission.....	207	191	168	229	211	167
All other ¹	338	393	396	340	399	416
Total.....	38,431	45,279	51,776	36,560	42,686	48,712

¹ Includes the Departments of Education, Justice, Labor, Housing and Urban Development and Treasury, the Tennessee Valley Authority, the Smithsonian Institution, the Corps of Engineers, and the Federal Emergency Management Agency.

increase will again provide "real" growth (over inflation) of about 6 percent over 1984 for basic research supported by the Federal Government.

For agencies supporting primarily basic research in the physical and engineering sciences, particularly the Department of Defense, the National Aeronautics and Space Administration, the National Science Foundation and the Department of Energy, the increase in 1985 over 1984 will average 14 percent.

Support for basic research by agencies principally supporting the life and other sciences, chiefly the Department of Health and Human Services, and the Department of Agriculture, will increase by an average of 5 percent, including a new emphasis on biotechnology in the Department of Agriculture.

This enhanced support of basic research serves to strengthen the ability of the Nation's academic research scientists to conduct high-quality research and to educate the next generation of scientists and engineers. University-based researchers receive about half of the total Federal obligations for basic research and provide the critical element of education to maintain a vigorous, first-class scientific and technical talent pool.

Table K-3 summarizes Federal support for the conduct of basic research by agency.

R&D FACILITIES

The availability of modern research facilities and equipment forms the foundation for the performance of high-quality research.

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Table K-3. CONDUCT OF BASIC RESEARCH BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars) ¹

Department or agency	Obligations			Outlays		
	1983 actual	1984 estimate	1985 estimate	1983 actual	1984 estimate	1985 estimate
Agencies supporting primarily physical sciences and engineering: ²						
National Science Foundation.....	1,000	1,173	1,330	932	1,072	1,288
Energy.....	912	1,039	1,230	904	1,010	1,134
Defense—Military functions.....	784	815	939	722	787	875
National Aeronautics and Space Administration.....	615	714	828	594	638	786
Interior.....	87	120	97	100	115	101
Commerce.....	19	21	18	19	19	19
Other Agencies ³	8	7	7	8	7	8
Subtotal.....	3,424	3,889	4,449	3,279	3,648	4,210
Agencies supporting primarily life and other sciences: ⁴						
Health and Human Services.....	2,473	2,783	2,914	2,319	2,591	2,800
(National Institutes of Health).....	(2,321)	(2,609)	(2,738)	(2,169)	(2,438)	(2,631)
Agriculture.....	362	387	420	355	387	397
Smithsonian Institution.....	54	60	66	54	58	64
Environmental Protection Agency.....	22	23	26	30	22	18
Veterans Administration.....	14	15	15	14	15	15
Education.....	13	11	14	14	19	16
Other Agencies ⁵	20	24	22	20	30	27
Subtotal.....	2,958	3,303	3,476	2,806	3,123	3,337
Total.....	6,383	7,193	7,925	6,085	6,771	7,547

¹ Amounts reported in this table are included in totals for conduct of R&D.² Includes mathematics and computer sciences.³ Includes the Corps of Engineers, the Federal Emergency Management Agency, the Tennessee Valley Authority, and the Department of Transportation.⁴ Includes psychology and social sciences.⁵ Includes the Departments of Labor, Justice, and Treasury, and the Agency for International Development.

In 1985, additional funding within the total for support for the conduct of R&D is provided for instrumentation, including the specialized research facilities at national laboratories and university centers that provide scientific opportunities for individual disciplines, e.g., particle accelerators, telescopes, and advanced computers.

Funds for R&D facilities are primarily for construction or renovation of general purpose laboratories and research support facilities.

In 1985, obligations for R&D facilities are expected to total \$1.3 billion, a decrease of \$132 million from 1984. Increases and decreases that are not reflective of trends in overall R&D support occur in a number of agencies. Significant changes in obligations for R&D facilities can occur from year to year due to completion of construction projects and normal cycles of site and building acquisition, renovation and repair.

Table K-4. RESEARCH AND DEVELOPMENT FACILITIES BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1983 actual	1984 estimate	1985 estimate	1983 actual	1984 estimate	1985 estimate
Energy.....	576	630	661	627	606	690
Defense—Military functions.....	308	446	369	263	333	367
National Aeronautics and Space Administration..	125	185	171	108	139	163
Agriculture.....	34	61	28	33	41	39
National Science Foundation.....	3	9	18	3	8	16
Health and Human Services.....	48	58	15	27	33	43
(National Institutes of Health).....	(18)	(42)	(14)	(23)	(19)	(29)
All other ¹	43	49	45	27	37	49
Total.....	1,137	1,439	1,306	1,087	1,197	1,367

¹ Includes the Departments of Transportation, Commerce, Interior, and Treasury, the Agency for International Development, Veterans Administration, Tennessee Valley Authority, and the Smithsonian Institution.

PART II. AGENCY R&D PROGRAMS

Presented below are summaries of the R&D activities of the 13 agencies whose R&D obligations individually exceed \$150 million.

DEPARTMENT OF DEFENSE

DOD research and development ranges from support of basic research, primarily in the physical sciences, to full scale development of hardware and its test and evaluation. The primary purpose of DOD R&D is to provide new strategic and tactical weapons and supporting systems to improve the Nation's defense. At \$34.2 billion, obligations for DOD research and development, including R&D facilities, comprise about 65 percent of total Federal funding for research and development in 1985.

In 1985, DOD obligations for the conduct of R&D will increase by \$6.2 billion to \$33.9 billion, or by 23 percent. DOD funding of basic research will increase 15 percent, from \$815 million in 1984 to \$939 million in 1985. Funding for R&D facilities will decrease by \$77 million in 1985 to a total of \$369 million. By mission category, major R&D efforts for 1985 include:

—*Technology Base and Advanced Technology Development.*—

These programs constitute the research end of the Department's Research and Development, Test and Evaluation spectrum. The programs are intended to provide choices for future system development and to help avoid technological surprise.

In order to meet the President's call for a long-term R&D program to explore possibilities of eliminating the threat of ballistic missile attack, increased emphasis will be placed on development of technologies for sensors, high-velocity missiles, and directed-energy systems. Other areas emphasized for re-

search include materials research, electronics, and environmental factors important to the military mission.

- Strategic Programs.*—Full scale development of the Trident II, Peacekeeper, and B-1 bomber will continue in 1985, as will strategic communications satellite development.
- Tactical Programs.*—These R&D programs support the development of systems to increase the capability of U.S. general purpose and theater nuclear forces, and to develop the capability to project force rapidly anywhere in the world where vital U.S. interests are threatened. In 1985 these programs include:
 - for the Army, development of a system to defend against tactical missiles, continued work on protective measures against chemical warfare and on remotely piloted vehicles, initiation of development of the new family of light rotorcraft, and increases in efforts on synthesis of battlefield intelligence information, and on control of air defense weapons.
 - for the Navy, development of an upgrade to the F-14 fighter aircraft, increased work on the J VX tilt rotor aircraft, initiation of development efforts for a new attack submarine, and continued work on the new DDG-51 destroyer and on a lightweight torpedo.
 - for the Air Force, continued work on a derivative model of an existing fighter aircraft, while also continuing work on the F-111 fighter-bomber avionics upgrade, the C-17 transport aircraft, deep interdiction systems, and an advanced medium-range air-to-air missile. In addition, development of navigation aids, control systems and communications systems will continue.
- Intelligence and Communications, Program Management and Support.*—R&D supported by these programs is directed toward improvements in defense intelligence systems, command control and communications programs, and test and evaluation capabilities. Work will continue in such areas as the use of technology to reduce manufacturing costs and to extend the life and capability of existing defense systems.

Table K-5 provides the details of the Department of Defense military R&D funding.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA makes investments in R&D programs primarily to improve the Shuttle-based Space Transportation System; to advance knowledge of the earth, the near-earth environment, the solar system and the universe; and to support long-term research and space technology advancement for low gravity materials science and satellite communications. It also supports long-term research and selected systems technology projects in aeronautics.

Table K-5. DEPARTMENT OF DEFENSE—MILITARY RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity	1983 actual	1984 estimate	1985 estimate
OBLIGATIONS			
Conduct of R&D:			
Research, development, test and evaluation:			
Tactical programs	7,206	8,159	10,045
Strategic programs.....	5,654	7,866	8,807
Intelligence and communications.....	2,663	3,321	4,213
Technology base.....	3,191	2,965	3,311
Advanced technology development.....	830	1,350	3,007
Program management and support.....	2,689	3,194	3,669
Other appropriations.....	691	780	801
Total conduct of R&D.....	22,925	27,636	33,852
Total conduct of basic research, included above.....	(784)	(815)	(939)
R&D facilities.....	308	446	369
Total obligations.....	23,233	28,082	34,221
OUTLAYS			
Conduct of R&D.....	21,057	25,310	31,053
R&D facilities.....	263	333	367
Total outlays.....	21,320	25,643	31,420

R&D accounts for about two fifths of the total NASA budget. The balance of the NASA budget provides primarily funding for Shuttle production and operations, tracking and data acquisition activities, and related institutional support.

In 1985, R&D obligations including facilities for the agency will exceed \$3.5 billion a net increase of \$70 million over 1984. Within this total, additional funds are available to complete projects currently under development, to augment major research and technology programs, and to initiate several major new space flight projects. Within the overall total for R&D, basic research obligations by NASA in 1985 are estimated at \$828 million, an increase of \$114 million, or 16 percent over 1984. Obligations for construction of R&D facilities in 1985 will decline to \$171 million because of extraordinary spend-out rates experienced in 1984.

Space Transportation.—Obligations for space transportation R&D are estimated to decrease by \$123 million in 1985, consistent with the completion of system improvements initiated in past years and the progress made in achieving a mature space transportation system. Major continuing activities in the 1985 budget will include development of the filament-wound rocket booster case for improved Shuttle performance; development of the Centaur upper stage—a new high energy upper stage for use with the Shuttle; and further development of the tethered satellite program, a Shuttle-based science program conducted in cooperation with the Italian

government. In addition, the 1985 budget provides for a follow-on program to efforts begun in 1984 that will modify and improve the operational Space Shuttle system, including a major multi-year effort to assure the reliability and cost-effective performance of the Shuttle main engines and to improve Shuttle support and auxiliary systems.

Also in 1985, \$150 million is proposed for the design and definition of a space station, planned for launch in the early 1990's. The space station is intended to enhance the Nation's science and applications programs, to help develop advanced technologies potentially useful to the economy, and to encourage greater commercial use of space.

Space Science and Applications.—Obligations for space science and applications are estimated to increase in 1985 by 11 percent, to \$1.4 billion. This increase will allow initiation of three major new flight projects, continued support of ongoing flight projects, and the analysis of scientific data being sent back to Earth from spacecraft now in space.

The 1985 budget continues support for space science research activities to improve understanding of the Sun, the planets, and the universe; space-related research on the earth's climate, resources, surface and atmosphere; research to advance knowledge in materials science and materials processing through low gravity experiments in space; and continuing long-term basic technology work for satellite communications.

Major new flight projects proposed for funding in 1985 include:

- the Mars Geoscience/Climatology Orbiter (MGCO) mission, a major new \$325 million Space Science project to continue the scientific exploration of the planet Mars.
- the Upper Atmosphere Research Satellite (UARS) spacecraft, a \$650 million project to investigate the chemical composition of the Earth's stratosphere and mesosphere.
- the Scatterometer project, a \$125 million research instrument to measure global wind patterns on the surface of the oceans. This instrument will be flown on a Navy satellite now under development.

Continuing development efforts for ongoing major flight projects yet to be launched include:

- the Space Telescope, planned for launch in 1986, which will serve as a major astronomy facility for a 15- to 20-year period.
- the Gamma Ray Observatory, planned for launch in 1988, which will enhance basic research in high energy astrophysics, providing new knowledge about objects in deep space.
- Spacelab astronomy experiments, which will be conducted on the Shuttle with the goal of improving our understanding of the Earth's vicinity, the Sun and the universe.

- the Galileo orbiter and probe mission to Jupiter, which will be launched in 1986 and arrive at Jupiter in 1988 to carry out long-term studies of the planet, its satellites, and its magnetosphere.
- the Venus Radar mapper project, planned for launch in 1988, to map the planet Venus.

Satellites now in space that are planned to be supported in 1985 include:

- two Voyager spacecraft, launched in 1977, which have successfully encountered Jupiter and Saturn, and Voyager 2 which will continue on its way to Uranus for an encounter in 1986.
- several other smaller scientific satellites now in space (e.g., the Earth Radiation Budget Satellite, and the International Ultraviolet Explorer).

The budget also provides for continuing research and technology work in areas such as ground-based space research; space-related life science research; near earth experiments using balloons and sounding rockets; research in geodynamics, ocean processes, and atmospheric dynamics; Shuttle-based science and applications experiments; and preparations for the future launch of planned missions. Continuing efforts to improve satellite communications technology will be refocused towards generic and longer term technology base efforts, in recognition of the responsibility of the private sector to pursue relatively near term satellite communications technologies.

Aeronautical Research and Technology.—Obligations for aeronautical research and technology are estimated to increase from \$323 million to \$365 million in the 1985 budget, primarily to augment ongoing research in fundamental aeronautical disciplines such as fluid and thermal physics, materials and structures, and propulsion and selected systems technology projects.

In 1985, increased funds are included to continue, as planned, the following ongoing development efforts:

- the X-wing rotorcraft project, a joint NASA/DOD project to develop the technology for future high speed rotorcraft using the X-wing rotor concept;
- the numerical aerodynamic simulator, which will allow greater use of advanced computational techniques to improve the productivity of aeronautical research and design; and,
- research and technology development related to the use of composite materials in large aircraft structures. These lightweight materials could result in longer range and more efficient military and civil aircraft.

Agency-wide support activities.—Obligations for agency-wide support activities will increase slightly above the 1984 level. These

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programs include primarily R&D-related NASA civil service and administrative costs, tracking and data acquisition system improvements, and R&D addressing fundamental space technology problems and opportunities common to a wide spectrum of space programs.

In 1985, space-related agency-wide support costs will total \$1,103 million, including aeronautics-related support costs of \$314 million. When aeronautics support costs, aeronautics-related facilities construction funding and aeronautics R&D are combined, total NASA support for aeronautics will reach \$717 million in 1985.

Table K-6 provides the details of NASA's R&D funding.

Table K-6. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—RESEARCH AND DEVELOPMENT
(In millions of dollars)

Type of activity	1983 actual ¹	1984 estimate	1985 estimate
OBLIGATIONS			
Conduct of R&D:			
Space transportation systems	365	626	503
Space science and applications.....	1,036	1,232	1,370
Aeronautical research and technology.....	277	323	365
Agency-wide support activities:			
Space research and technology.....	120	143	149
Tracking and data acquisition.....	13	72	15
Research and program management.....	759	861	939
Total conduct of R&D.....	2,570	3,257	3,341
Total conduct of basic research, included above.....	(615)	(714)	(828)
R&D facilities.....	125	185	171
Total obligations.....	2,695	3,442	3,512
OUTLAYS			
Conduct of R&D.....	2,538	3,462	3,314
R&D facilities.....	108	139	163
Total outlays.....	2,646	3,600	3,477

¹ Production, operating and support costs of the space shuttle are excluded from the 1983 amounts. In 1984 and 1985 these costs are funded in the new appropriation "Space Flight, Control and Data Communications"

DEPARTMENT OF ENERGY

The R&D programs of the Department of Energy include: a *National Defense Program* related to the development and testing of nuclear weapons; a *General Science Program* of basic research in high energy physics and nuclear sciences; and an *Energy Program* focused on long-term R&D in support of energy technology development. Table K-7 provides summary information on the funding of these programs.

Obligations for the conduct of energy related R&D are estimated to total \$4.9 billion in 1985, an increase of \$41 million from 1984. Obligations in 1985 for R&D facilities, including the construction or

upgrading of general purpose laboratories and other research support facilities, will amount to \$661 million.

Obligations for the conduct of basic research, included in the total for the conduct of R&D, are estimated to be \$1.2 billion in 1985, an increase of \$191 million over 1984. Within the basic research total, funds are provided to continue or initiate a number of major projects in both the energy program and the general science program, that will enhance the Nation's capacity for basic research.

The *National Defense Program* primarily supports the continued development and testing of nuclear weapons. It also supports the development of improved technologies for monitoring nuclear weapons treaties and of improved methods for safeguarding nuclear materials. In addition, R&D efforts will continue in developing methods for the safe storage and disposal of radioactive wastes resulting from weapons production and research on improved propulsion reactors for naval vessels. Obligations for the national defense program for the conduct of R&D will increase from \$1.9 billion in 1984 to \$2.0 billion in 1985. Funds for R&D facilities in 1985, \$501 million, include construction of the Waste Isolation Plant (WIPP) in New Mexico for R&D on disposal of nuclear waste. Increased funding for conduct of R&D provides for continued R&D in isotope separation techniques, for increased weapons testing, and for increased research in the basic physics of nuclear weapons and in advanced weapons concepts.

The *General Science Program* supports basic research in high energy and nuclear physics. A proposed increase of \$105 million, to \$744 million in 1985, for the conduct of basic research will enhance support for experimental efforts to understand the basic constituents of matter and energy and the forces that govern their interaction.

The 1985 budget request will provide for:

- increased utilization of existing accelerator facilities, including operation of the newly completed (1983) Energy Saver Superconducting Synchrotron at Fermilab in the 500-1,000 GeV energy range;
- completion of the construction at Fermilab of the Tevatron II (proton accelerator) and continuation of the Tevatron I (proton-antiproton colliding beam) project;
- completion of accelerator upgrades at the University of Washington and Yale University;
- continued construction of the Stanford Linear (electron-positron) Collider and the upgrade of existing accelerators at Brookhaven National Laboratory; and,

- planning for the construction of an advanced nuclear physics electron accelerator facility at Newport News, Virginia sponsored by the Southeastern Universities Research Association.

The budget also includes funds for continuation of preliminary research and development activities for the design of a possible next-generation high-energy particle physics accelerator.

The *Energy Program* is focused in 1985 on basic and other longer term R&D to complement industry investments in new or improved energy technologies. It funds the development of selected technologies of a high risk but potentially high payoff nature, such as magnetic fusion, where significant private investment is unlikely. In addition, the energy program supports research on the environment and human health effects of energy production technologies. Energy program obligations for the conduct of R&D will decrease from \$2.3 billion in 1984 to \$2.1 billion in 1985. Obligations for R&D facilities in this program will be \$160 million, a decrease of nearly \$20 million from 1984.

In the *basic energy sciences*, funding for the conduct of R&D will increase by \$82 million to \$420 million in 1985 for research in such fields as nuclear science, chemistry, engineering, materials science, applied mathematics, biology, and the geosciences. This program provides the fundamental scientific and technical base for future advances in both nuclear and non-nuclear technology development. In addition, it provides support for the operation of several unique national facilities that are used by researchers from industry, universities and national laboratories. These include the National Synchrotron Light Source at the Brookhaven National Laboratory, the High Voltage Electron Microscope at the Lawrence Berkeley Laboratory, and the Intense Pulsed Neutron Source facility at Argonne National Laboratory.

The 1985 budget provides for the continuation of construction projects initiated in 1984, including the Center for Advanced Materials at the Lawrence Berkeley Laboratory, expansion of the National Synchrotron Light Source at Brookhaven, and the upgrade of the Stanford Synchrotron Radiation Laboratory facilities. The budget also provides for:

- initiation of construction of an Ion Collision Physics Facility at Kansas State University, with the university providing the funds for the construction necessary to house both the superconducting (LINAC) booster accelerator and the charged source to be added to the existing tandem Van de Graaff generator; and,
- expansion of the applied mathematics computational research program, including the purchase of a supercomputer and associated network access equipment to provide Department of Energy research contractors (university, industry, and

national laboratory scientists) access to state-of-the-art computational capabilities.

The 1985 budget will continue the redirection of the non-nuclear R&D programs to limit federal support to longer-term generic research and place greater reliance on the private sector for support of nearer term technology development. Obligations for the conduct of R&D in the *fossil, solar/renewables* and *conservation* programs are expected to be \$646 million in 1985, a decrease of about \$100 million from 1984.

Funding for the conduct of *fossil* related R&D and associated facilities will be \$273 million in 1985, a decrease of \$57 million. The 1985 budget is focused on research to improve technologies for utilizing coal and for developing means of recovering oil and gas from unconventional sources (e.g., lenticular sands, or shale and tar sands). Support continues to be provided in such areas as the chemistry of coal conversion, environmental controls, combustion research, and the static and dynamic characteristics of oil and gas resources. Included in the budget is \$7 million to initiate work on acid rain control technology options. This work is supported by a base program, generally applicable to acid rain control research, of \$48 million.

Research in support of *solar and other renewable energy* technologies, proposed at a level of \$227 million, will emphasize longer term, technology base R&D in areas such as photovoltaics, solar thermal energy, biofuels, wind and geothermal energy, electrical energy systems, and energy storage. The total request for the *energy conservation* R&D program is \$146 million, which includes \$11 million to complete construction of a new High Temperature Materials Laboratory at the Oak Ridge National Laboratory. Research to foster energy conservation in buildings and community systems, industry, and transportation will continue. Emphasis will be given to generic research in such areas as combustion, materials science, and tribology.

The 1985 budget continues to provide for a broad program of research in nuclear *fission* and *fusion* energy technologies. Total obligations for these R&D programs will be about \$1.1 billion in 1985, a decrease of \$46 million from 1984. Conduct of R&D will total approximately \$1.0 billion and funding for related facilities will be \$81 million. The overall decrease proposed for these nuclear-based energy programs reflects primarily the effect of termination of the Clinch River Breeder Reactor project.

In the *magnetic fusion* program, funding of \$483 million for the conduct of R&D will support continued construction of the large mirror test facility (MFTF-B); operation of the large tokamak test reactor (TFTR) and the smaller Doublet and Alcator-C tokamaks; and research into key physics issues involved in the confined plas-

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mas. R&D on superconducting magnets, high power radiofrequency electronics, advanced materials development, and mathematical computer modeling needed for fusion technology development will also be continued.

Within the fission effort, totaling \$618 million for the conduct of R&D and associated facilities in 1985, the *breeder reactor* program is proposed at a level of \$296 million for 1985. The program will be redirected towards development of a technology base and investigation of new concepts to assist private industry in the development of possible future commercial plants. Other nuclear fission research areas such as *converter reactor systems* and *nuclear systems for space applications* are funded at \$117 million in 1985.

Additional funds are proposed for nuclear safety and *commercial nuclear waste* management research. For example, in cooperation with the Nuclear Regulatory Commission, technical investigations associated with the disabled Three Mile Island nuclear power reactor will be supported. The *fission* R&D program will also seek to resolve technical issues associated with the technology of nuclear waste storage and disposal and consequent environmental impacts. Obligations for these activities in 1985 are \$67 million, a 10 percent increase over 1984.

Funds for the *uranium enrichment* R&D program for 1985 total \$115 million. This program develops advanced technologies for separation and enrichment of uranium. In 1985, DOE will choose between the Atomic Vapor Laser Isotope Separation process and the Advanced Gas Centrifuge process for future development and demonstration. As a result of this decision, the program will become more narrowly focused and funding requirements can be reduced by \$74 million from the level appropriated in 1984.

Finally, the energy program supports R&D to determine the biological and environmental effects of energy production and use. The *biological and environmental research* R&D emphasizes the health effects of radiation, the use of radiation in medical diagnosis and therapy, and generic biological research related to radiation and other cellular traumas. This effort also supports research to determine the relationship between the CO₂ content of the atmosphere and the Earth's climate changes. The level of obligations for such activities will be \$189 million in 1985. Funding in 1985 for acid rain related and carbon dioxide related research is over \$20 million.

Table K-7 provides the details of the Department of Energy.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

The Department of Health and Human Services will increase obligations in 1985 for the conduct of R&D by \$91 million over the 1984 level to a total of \$5.0 billion. Within this total, funding for

Table K-7. DEPARTMENT OF ENERGY

(In millions of dollars)

Type of activity	1983 actual	1984 estimate	1985 estimate
OBLIGATIONS			
Conduct of R&D:			
National defense program.....	1,575	1,858	1,994
General science program.....	568	639	744
Energy program.....	2,348	2,347	2,147
Total conduct of R&D.....	4,491	4,844	4,885
Total conduct of basic research, included above.....	(912)	(1,039)	(1,230)
R&D facilities.....	576	630	661
Total obligations.....	5,067	5,474	5,546
OUTLAYS			
Conduct of R&D.....	4,771	4,853	4,744
R&D facilities.....	627	606	690
Total outlays.....	5,398	5,459	5,434

basic research is estimated to be \$2.9 billion. Obligations for R&D facilities will total \$15 million in 1985.

Health.—Over 87 percent of the Department's funds for the conduct of R&D will be obligated by the National Institutes of Health for biomedical research to advance the Nation's capabilities for the prevention, diagnosis, and treatment of disease. Several other agencies within the Department—the Alcohol, Drug Abuse, and Mental Health Administration, the Food and Drug Administration, the Centers for Disease Control, the Health Resources and Services Administration, the Health Care Financing Administration, and the Office of the Assistant Secretary for Health—also support health-related research.

The *National Institutes of Health (NIH)* consist of 11 separate Institutes which will obligate \$4.3 billion in 1985 for the conduct of R&D, an increase of \$102 million above the 1984 level. Increased emphasis will be given to support of basic research in 1985. Over one-half, or \$2.7 billion, of NIH's proposed R&D budget will support basic research, an increase of \$129 million over 1984.

Among the most significant R&D activities to be supported by NIH are:

- basic research on cancer chemoprevention including studies of nutritional factors; rehabilitation of patients with chronic obstructive pulmonary disease; prevention of glaucoma; diagnostic imaging; biological response to chemicals; immunology and neurobiology, including development and application of molecular biology techniques;
- clinical research where the emphasis is on medical intervention in the disease process, including prototype development

and refinement of products, techniques, processes, methods, and practices;

- an expanded program of cooperative clinical trials on the Acquired Immunodeficiency Syndrome/Kaposi's Sarcoma problems; isolated systolic hypertension in the elderly; herpes simplex virus vaccine; antiviral drugs against neonatal herpes, herpes encephalitis, and genital herpes; the efficacy of interferon for controlling the frequency and severity of multiple sclerosis; gonococcal vaccines and the prevention of premature labor, and the role of folic acid in neural tube defects; and,
- increased basic clinical research into the cause, cure, and prevention of diabetes.

The *Alcohol, Drug Abuse and Mental Health Administration (ADAMHA)* conducts studies on the causes, prevention and treatment of alcohol and drug abuse and mental disease and neurological disorders, with emphasis on improving knowledge of effective prevention of these public health problems.

The 1985 budget proposes increases in ADAMHA for extramural research programs in biomedical, behavioral and clinical areas. Obligations will increase in 1985 to \$355 million, \$9 million over 1984.

Specific research areas to be addressed include:

- neurosciences, behavioral sciences, psychopharmacology, and clinical investigations and evaluations of services to the mentally ill, with special emphasis on preventing and diagnosing mental and emotional problems in children;
- drug abuse among the Nation's youth, including studies on the adverse health hazards of marijuana and cocaine; and,
- causes and consequences of alcohol abuse, particularly among teenagers.

The *Food and Drug Administration* supports research relevant to its mission of regulating food, drugs, and biological and radiological products. In 1985, obligations for these activities are estimated at \$81 million.

The *Centers for Disease Control* support studies on the epidemiology and control of communicable diseases and on health promotion and disease prevention. In 1985, obligations for these activities are estimated at \$84 million.

Other Health Related Agencies within the Department support research in areas such as the effect of socioeconomic factors on social security programs and the economy; survey methods and techniques for analysis of health statistics; and the organization, delivery, and financing of health services. This support is provided through programs of the Health Resources and Services Administration, the Office of the Assistant Secretary for Health and the Health Care Financing Administration.

Human Services.—The Department's obligations for R&D in human services programs in 1985 will be \$31 million. The proposed budget will support a variety of developmental and social services research aimed at improving: the Head Start program; the quality of life for the elderly; knowledge of child abuse and neglect; day care systems; family and community support systems; and fostering independence of the disabled.

The Table K-8 provides details of the R&D funding of the Department of Health and Human Services.

Table K-8. DEPARTMENT OF HEALTH AND HUMAN SERVICES—RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity and organizational units	1983 actual	1984 estimate	1985 estimate
OBLIGATIONS			
Conduct of R&D:			
Health:			
National Institutes of Health	3,788	4,240	4,342
Alcohol, Drug Abuse, and Mental Health Administration	302	346	355
Food and Drug Administration	74	79	81
Centers for Disease Control	78	84	84
Health Care Financing Administration	30	35	35
Office of the Assistant Secretary for Health	16	18	16
Health Resources and Services Administration	9	10	5
Subtotal, Health	4,298	4,811	4,919
Human Services:			
Social Security Administration	11	17	17
Office of Human Development Services	24	21	6
Departmental Management	15	10	9
Subtotal, Human Services	50	47	31
Total conduct of R&D	4,348	4,859	4,950
Total conduct of basic research, included above	(2,473)	(2,783)	(2,914)
R&D facilities	48	58	15
Total obligations	4,396	4,917	4,964
OUTLAYS			
Conduct of R&D	4,092	4,529	4,869
R&D facilities	27	33	43
Total outlays	4,119	4,562	4,913

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) supports primarily basic research in all disciplines through grants to scientists and engineers in academic institutions. NSF support is particularly important because it complements the basic research programs of other agencies and assists in balancing Federal support for promising research across all fields of science and engineering.

The 1985 NSF budget includes \$1.4 billion in obligations for the conduct of R&D, an increase of \$169 million or 14 percent above 1984. Within this total, support for basic research will increase by more than 13 percent.

The principal growth in the 1985 budget will be in the support of basic research at academic institutions through project grants. Within the proposed increase of \$112 million for this purpose, emphasis will be given to strengthening support for the physical sciences in disciplines such as mathematics, physics and chemistry, for engineering and for molecular and cell biology. Additional studies of the continental lithosphere will be funded, including investigations of potential future lithospheric and seismological projects. Emphasis will also be given to further improving university research instrumentation across all disciplines. Together with the increases provided for instrumentation in 1984, support for instrumentation by NSF will have increased over 95 percent in the period 1983-1985.

In addition, the 1985 budget will provide increased funds:

- to initiate a new program of support for centers for cross-disciplinary research in the engineering disciplines, i.e., chemical, mechanical, electrical, at universities. Research in these disciplines has the potential to make important contributions to the long-term competitiveness of the U.S. economy, particularly in high technology dependent industries. In addition, these funds will provide enhanced opportunities for the training of future engineers;
- to increase the access of academic scientists to supercomputers. This will help to enhance the productivity of U.S. research scientists by providing not only supercomputer time and technical support, but also support for communications, equipment and other costs for remote access by scientists at their university laboratories;
- to support, as a related effort, the acquisition of the Advanced Vector Computer at the National Center for Atmospheric Research. This computer will be a Class VII supercomputer with many times the speed and memory capability of the class of supercomputers now available and will serve the special needs of the atmospheric and ocean sciences communities; and,
- to initiate the construction of the Very Long Baseline Array radiotelescope. This unique instrument will further advance radioastronomy by providing scientists with at least 100 times the resolving power now available. Objects such as stars, quasars and pulsars will be observable in much greater detail.

DEPARTMENT OF AGRICULTURE

The Department of Agriculture supports research and development in several disciplines related to agriculture and forestry to ensure the continued high productivity of U.S. agricultural and forest lands.

Obligations of the Department for the conduct of research and development are expected to total \$898 million in 1985, compared to the \$872 million in 1984. Of the total, \$420 million will support basic agricultural research, an increase of \$33 million over the 1984 estimated levels. The Department's 1985 Budget for research and development is highlighted below by major bureau.

The *Cooperative State Research Service (CSRS)* estimates that \$257 million will be obligated in 1985 for the conduct of research and development. This represents an increase of \$19 million over the current year. CSRS supports research on agriculture, forestry, the rural home, and the rural community primarily through grants to land-grant colleges. Also, within CSRS, the Competitive Research Grants program funds basic research, based on proposals from scientists in academic institutions or the private sector, in the areas of plant and animal science, human nutrition and biotechnology.

The CSRS 1985 budget proposes \$50 million in the Competitive Research Grants program, including \$28.5 million for new basic research initiatives in biotechnology. Much of the current research in biotechnology has been done using bacteria and animals such as mice. Although some recent progress has been made using plants, basic life processes in commercially important plant species are still poorly understood. The application of biotechnology to important plant species offers tremendous promise to deliver the technology needed to increase both the efficiency of agricultural production and farmers' profits. The need for resources, such as water and fertilizer, needed to produce commercially important species could be substantially reduced through advances in areas such as nitrogen fixation, photosynthesis, and resistance to pests, disease and environmental stress.

The proposed budget for 1985 recognizes that research investments in agricultural biotechnology are necessary to retain the U.S. competitive edge in agricultural production. Agriculture accounts for 20 percent of the GNP and represents a large share of export earnings.

The *Agricultural Research Service* expects to obligate \$467 million in 1985 to conduct basic and applied research in the areas of livestock and plant science; pest control; use and improvement of land, water, and air resources; and research on human nutrition and consumer services. This is an increase of \$14 million in obligations over 1984.

In 1985 increased emphasis will be placed on basic research on animal and plant production efficiency; land and water conservation; post-harvest technologies; and higher education.

The *Forest Service* estimates that \$103 million will be obligated for research and development in 1985. This represents a decrease of \$6 million from 1984. The long-range goal of forestry research is to provide the information needed to manage and protect forest and range land resources, and to gain maximum economic and social benefits from their use.

Other Departmental Programs will obligate approximately \$72 million for R&D in 1985 covering a broad spectrum of research activities, such as research in agricultural economics, international agricultural cooperation, and statistical reporting.

DEPARTMENT OF COMMERCE

The Department of Commerce undertakes research primarily in ocean science and engineering, meteorology and weather forecasting, and in the maintenance of measurement standards to support science and industry.

Obligations for the conduct of R&D by the Department in 1985 are estimated at \$272 million, a decrease of \$85 million from 1984. This reflects less involvement in applied research and development by the National Oceanic and Atmospheric Administration and the National Bureau of Standards which is more appropriately the responsibility of other sectors that profit directly from these R&D investments.

National Oceanic and Atmospheric Administration (NOAA).—NOAA obligations for the conduct of research and development will decrease from \$242 million to \$167 million as a result of greater reliance on support from the private sector and State and local governments, and elimination of lower priority research. NOAA will continue R&D programs on systems and components for nautical and aeronautical mapping and charting; ocean engineering systems in support of NOAA ocean research and operational programs; better ways to conserve, protect, and manage the Nation's fishery resources; new and improved fishing equipment to protect endangered and/or threatened species; and on timely and accurate meteorological, hydrologic, and oceanographic forecasting, detecting and tracking systems for protection of life and property.

National Bureau of Standards (NBS).—NBS conducts research aimed at maintaining and improving a system of measurement required to support the Nation's industrial and scientific endeavors.

In 1985, NBS is expected to obligate \$91 million for the conduct of R&D. This represents a decrease of \$5 million from 1984. Funding will increase to support new work in manufacturing process

and quality control and biotechnology. In addition, acquisition of two new facilities, a cold neutron source, used for research in materials science, and an advanced scientific computer will be initiated in 1985. Funding for several programs, including fire and building research, will be terminated or reduced because such research can and should appropriately be supported by other sectors.

Other Commerce R&D Activities.—Funding for smaller research and development programs in the Department of Commerce, which include those in General Administration, the Bureau of the Census, the Patent and Trademark Office and the National Telecommunications and Information Administration, are proposed at \$14 million in 1985, a decrease of \$5 million from the 1984 level.

DEPARTMENT OF THE INTERIOR

The R&D activities of the Department of the Interior principally derive from its broad-ranging responsibilities for management of the Nation's natural resources, including developing energy and mineral resources, and restoring and preserving wildlife habitats. R&D programs also serve the needs of other Federal agencies and the private sector.

Obligations for the conduct of R&D for the Department of the Interior for 1985 are estimated at \$363 million. This represents a decrease of \$52 million from the 1984 level and reflects reductions in activities more appropriately supported by the private sector or States.

Almost 90 percent of the Department's 1985 funds for the conduct of R&D will be obligated by the Geological Survey (\$148 million), Fish and Wildlife Service (\$111 million), and the Bureau of Mines (\$69 million). Highlights of the 1985 research objectives of these and other departmental programs are described below.

The *Geological Survey* undertakes research on the extent, distribution, and character of the Nation's natural resources and on the geologic processes, structures, and hazards that affect the development and use of the land and physical environment. For 1985, obligations will decrease by \$13 million, to a total of \$148 million, reflecting elimination of grants to State water research institutes, and reductions in coal hydrology research, activities more appropriate for support by States and the private sector. Volcano hazards research funding will also decrease to reflecting completion of the highest priority hazards assessments in the Cascades Range.

Research in 1985 will be directed toward:

- accurate appraisals of mineral resources and new improved methods of mineral exploration;
- development of basic data on geologic principles and processes;

- improving the scientific basis for appraisal and evaluation of water resources, including the effects of underground waste storage; and
- developing and applying new technology, including remote sensing, to prepare cartographic information.

The *Fish and Wildlife Service* supports research in the Service's laboratories and field stations and cooperative efforts with State fish and game departments. It also provides Federal aid to States for research on restoration of fish and wildlife resources. This research provides basic biological information about species numbers, population dynamics, ecological relationships, and habitat requirements. Obligations will increase by \$5 million in 1985 to a total of \$111 million. Major increases are proposed for Federal aid to State fish and wildlife agencies and for acid rain studies. Fish and Wildlife Service will support research activities concerned with:

- the habitats of waterfowl, migratory and non-migratory birds, and mammals;
- the status and distribution of endangered and threatened species;
- impact of broad-scale environmental changes on fish and wildlife populations and habitat; and
- diseases of freshwater and anadromous fish.

The *Bureau of Mines* conducts basic and applied research across the minerals cycle to improve understanding of the principles of mining and minerals processing and to reduce associated health hazards. Obligations for the conduct of R&D are expected to decrease by \$41 million to \$69 million in 1985. Most of this decrease in obligations is the result of an unusually high obligation level in 1984 because of large carryover balances from 1983. Other reductions are proposed in applied research, particularly in projects which are more appropriate for support by the private sector, and the Mineral Institutes program, involving some 30 state universities, which is now more appropriately supported by the private sector or individual State governments. The 1985 budget reflects continued emphasis on strategic and critical minerals R&D activities and stresses:

- long-range, high-risk research in extractive metallurgy technology that may result in new processing methods;
- development of domestic source substitutes for imported strategic and critical minerals;
- health-related research on the proper quality and quantity of air flow in underground mines; and,
- longer-term, generic research on fire and explosion prevention, methane and ground control, industrial hazards, post-

disaster survival and rescue, explosives, and systems engineering.

Other Departmental Programs expect to obligate about \$36 million in 1985, a decrease of \$3 million from 1984, and will provide for:

- development of technology to generate additional water supplies by cloud seeding techniques; and,
- natural resource investigations to improve scientific information available to park managers.

DEPARTMENT OF TRANSPORTATION

The R&D program of the Department of Transportation is oriented toward providing the information and new technology needed for its own operational (e.g., air traffic control) programs and for regulatory (e.g., automotive and aircraft safety standards) programs. Obligations for the conduct of research and development by the Department are estimated at \$498 million for 1985, a decrease of \$21 million from 1984.

The *Federal Aviation Administration* (FAA) will obligate \$277 million in 1985, a decrease of \$3 million from 1984. A major portion of the funding effort occurs in the air traffic control, advanced computer, aviation weather and aircraft safety activities. Work will be directed at improving safety and efficiency of aviation through major developments in en route air traffic control, development of hazardous weather detection devices, and aircraft safety research.

The *National Highway Traffic Safety Administration* (NHTSA) The 1985 budget proposes \$63 million for research and development activities, including passenger vehicle research, highway safety research, the National Center for Statistics and Analysis, highway safety program demonstrations, and consumer programs. This represents an increase in obligations of \$6 million over 1984.

Additional funds in 1985 will be used to intensify highway safety efforts to increase safety belt usage and decrease the incidence of drunk driving. For passenger vehicle research, increases are proposed to improve the understanding of the relationship between passenger vehicle design and manufacture to accident involvement and injury reduction. Increased analysis of accident and injury data will also be performed by the National Center for Statistics and Analysis.

The *Urban Mass Transportation Administration* (UMTA) conducts research, development and demonstration (RD&D) in all phases of urban mass transportation. In addition, UMTA supports interdisciplinary programs of research at colleges and universities in the problems of urban transportation.

In 1985, UMTA expects to obligate \$38 million, a decrease of \$11 million from 1984. The decrease is due primarily to the curtailment

of support for research on advanced forms of mass transportation, such as "people movers."

The *Federal Highway Administration* (FHA) proposes to obligate \$60 million in 1985. This represents a \$5 million increase over 1984, primarily to continue research programs in highway planning, design, construction, and maintenance. Research will also be started to identify and correct impediments to highway safety and to improve truck safety.

In 1985, the *Federal Railroad Administration* (FRA) will obligate \$16 million for research and development. Although this represents a decrease of \$16 million in obligations from 1984, the obligational level in 1984 was artificially high because of a large carryover balance from 1983. Taking this into account, obligational authority in 1985 is essentially equal to 1984.

The *Maritime Administration* (MarAd) research and development program will obligate \$11 million in 1985 to improve the competitive posture of the U.S. Maritime industries. This is a decrease of \$2 million from the 1984 level, reflecting a reduction in applied research projects more appropriate for support by the private sector.

The *U.S. Coast Guard* (USCG) will obligate \$24 million to support research to maintain and improve search and rescue systems, environmental protection, marine safety, enforcement of laws and treaties, aids to navigation, and activities which benefit all Coast Guard programs. The proposed 1985 budget represents an increase of \$1 million over the 1984 level.

The *Research and Special Programs Administration* will obligate \$3 million in 1985 for R&D in hazardous materials, pipeline safety, radionavigation, transportation statistics, and emergency transportation. This represents a decrease of \$2 million and is attributable to the transfer of the University Research Program to the Office of the Secretary.

The *Office of the Secretary* expects to obligate \$7 million for R&D activities in 1985, an increase of \$2 million over 1984. These activities include research on domestic and international transportation policy, the University Research Grants Program for long-range transportation research, grants to historically Black colleges and universities for transportation research, and support for the other R&D activities of the Department and for States and localities.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) conducts research and development in support of its responsibilities to protect human health and the environment. The 1985 budget proposes \$281 million in total obligations which represents an increase of \$31 million, or 12 percent, over 1984. The major thrusts for 1985 include:

(1) greatly expanded acid deposition research; (2) strengthened health risk assessment and environmental engineering capabilities; and, (3) an enhanced hazardous waste research program.

The *acid rain/energy research program* will be increased to address the need for more reliable information. The program expands basic research in areas identified by the Interagency Task Force on Acid Precipitation to provide enhanced data on the physical and chemical mechanisms governing the acid deposition phenomenon. This involves additional research on aerometric tracers, monitoring trends, and mitigation measures. In addition, the development and demonstration of the Limestone Injection Multistage Burner (LIMB) control technology for controlling sulfur emissions will continue in cooperation with industry.

The *Superfund research program* will be increased to support additional field testing of cleanup technologies, expand quality assurance activities for the National Contract Laboratories Program, and provide technical assistance for industry-EPA settlement agreements for cleanup of abandoned hazardous waste sites.

The *hazardous waste research program* will be increased to evaluate treatment alternatives to land disposal, disposal techniques for high-hazard wastes, and sampling devices for detecting organic compounds in incinerator emissions. Analytic methods for identifying hazardous wastes as well as groundwater fate and transport models will be validated. Finally, health effects tests to identify wastes as hazardous will be developed.

The *air research program* will be increased to conduct epidemiology studies on health problems related to exposure from oxidants. An integrated effort to determine the potential contribution of air pollution to the risk of cancer in the United States will be initiated. Development of health assessment documents for all 37 pollutants on the hazardous air pollutant priority list will be accelerated. Finally, research to evaluate emission reduction technologies for sulfates, particulate matter and volatile organic compounds will be accelerated.

The *water quality research program* is sustained at the 1984 level to support EPA and the States in implementing water quality standards and permits, and in managing the impacts of ocean disposal. Research in the municipal wastewater program will focus on compliance problems of municipal treatment plants, methods to reduce sludge volume, and new methods to upgrade plants. Industrial wastewater research will continue to concentrate on supporting implementation of the National Pollutant Discharge Elimination System permit program, particularly in the area of monitoring and quality assurance.

The *drinking water research program* will continue to support the development of drinking water Maximum Contaminant Levels

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(MCLs) and Health Advisories. Additional quality assurance for drinking water laboratories will be provided. Initial field testing of groundwater fate and transport models will begin to enable EPA and the States to better protect groundwater.

The *pesticides research program* will be increased to support revalidation of the pesticide chemical repository, the development of new health effects and environmental test methods, and the evaluation of applicator protective clothing.

The *toxic substances research program* will be increased for a new integrated effort on genetically engineered organisms (biotechnology), enhancement of predictive risk test methods, improvements in quality assurance, and improvements in monitoring methods.

NUCLEAR REGULATORY COMMISSION

The Nuclear Regulatory Commission (NRC) performs research dealing with the civilian uses of nuclear materials and facilities consistent with protecting the public health and safety, environmental quality, and national security. The goal of the program is to provide objectively verifiable safety and analytical methods which meet the needs of licensing and regulatory activities.

In 1985, the obligations of the Commission for the conduct of R&D are expected to decrease from \$191 to \$168 million. This decrease reflects the completion of a number of projects in 1984, including the planned shutdown of the Power Burst Reactor Facility and the completion of the cooperative Upper Plenum test program. Advanced reactor work will also be reduced primarily as a result of the cancellation of the Clinch River Breeder Reactor. In addition, research on large and small break loss-of-coolant accidents will be curtailed because this work is more appropriate for funding by the private sector.

VETERANS ADMINISTRATION

The Veterans Administration (VA) conducts and administers medical, rehabilitation, and health services research designed to improve the quality and increase the effectiveness of health care for the veteran. In 1985, the VA will obligate \$198 million for the conduct of R&D. This is a decrease of \$25 million below 1984 due primarily to a transfer of the major Agent Orange epidemiologic study to the Centers for Disease Control. The core research programs in the VA will increase by 12 percent in 1985.

The VA *biomedical research program* covers a wide range of medical problems, with special emphasis on Agent Orange, aging, alcoholism, post-traumatic stress, and the health problems of female veterans and former prisoners of war. The 1985 request includes funds for continuation of an epidemiological study on the health effects of exposure to Agent Orange and service in Vietnam.

This study is now being conducted by the Centers for Disease Control and received primary funding of \$54 million in 1984.

Rehabilitation research focuses on the problems of the disabled veteran and develops sensory aids for impaired vision and hearing. This work brings the latest electronic and computer technology to bear on problems of prosthetics, orthotics, wheelchair design, and spinal cord injury (including functional electrical stimulation of muscles in paralyzed limbs).

Health services research is designed to help health care professionals and managers to improve the effectiveness, economy, and accessibility of health care services provided to the veteran. Research in this area deals with such areas as aging and preventive medicine.

AGENCY FOR INTERNATIONAL DEVELOPMENT

Research and development activities of the Agency for International Development (AID) consist mainly of applied research to solve specific problems associated with basic human needs and social and economic research aimed at improving U.S. and host-country understanding of the barriers to development. Programs under AID reflect the administration's recognition of the importance of R&D in addressing the problems faced by the Third World. Over the years, AID has provided substantial support to research efforts undertaken by U.S. universities and international research centers such as the International Rice Research Institute in the Philippines.

Obligations by AID for the conduct of R&D are estimated at \$264 million for 1985, an increase of \$39 million over 1984.

The majority of the increase will provide enhanced support for research to improve agricultural production capability, with an emphasis on efforts to overcome the mounting food crisis in Third World nations. R&D funds will also be devoted to two other critical problems: population growth, emphasizing methods of controlling increasing population growth rates in the developing countries, and energy supply, emphasizing renewable and nonconventional energy sources critical for development to proceed.

Significant research efforts are also being pursued in two other promising areas: oral rehydration therapy and a malaria vaccine. The former holds the promise of significantly reducing the incidence of child mortality associated with diarrheal diseases, currently estimated to claim the lives of over 1 million children annually. Similarly, AID-supported research on a malaria vaccine may lead to a breakthrough in controlling a disease which currently infects some 200 million people worldwide and is the leading cause of death in Third World nations.

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OTHER AGENCY PROGRAMS

An additional 9 departments and agencies (listed in table K-2, footnote 1) will obligate an estimated \$396 million in 1985, for the conduct of R&D, an increase of \$3 million over the 1984 total. Obligations by these agencies amount to less than 1 percent of all federally-funded programs in R&D. The programs of these agencies, like those of other agencies discussed above, are closely related to serving the agencies' missions.

Among the agencies in this category that expect to increase their obligations for R&D in 1985 are the Smithsonian Institution, the Federal Emergency Management Agency, the Tennessee Valley Authority, the Corps of Engineers and the Departments of Labor, Treasury, and Housing and Urban Development.

Table K-9 provides information on the long-term trends in Federal funding for the conduct of R&D.

Table K-9. TRENDS IN CONDUCT OF R&D

(Obligations in billions of dollars)

Year	Defense ¹	All other	Total	Basic research ²
1960.....	6.1	1.5	7.6	0.6
1961.....	7.0	2.1	9.1	0.8
1962.....	7.2	3.1	10.3	1.0
1963.....	7.8	4.7	12.5	1.2
1964.....	7.8	6.4	14.2	1.3
1965.....	7.3	7.3	14.6	1.4
1966.....	7.5	7.8	15.3	1.6
1967.....	8.6	7.9	16.5	1.8
1968.....	8.3	7.6	15.9	1.8
1969.....	8.4	7.2	15.6	1.9
1970.....	8.0	7.3	15.3	1.9
1971.....	8.1	7.4	15.5	2.0
1972.....	8.9	7.6	16.5	2.2
1973.....	9.0	7.8	16.8	2.2
1974.....	9.0	8.4	17.4	2.4
1975.....	9.7	9.3	19.0	2.6
1976.....	10.4	10.4	20.8	2.8
1977.....	11.9	11.6	23.5	3.3
1978.....	12.6	13.2	25.8	3.7
1979.....	13.6	14.5	28.1	4.2
1980.....	15.1	14.7	29.8	4.7
1981.....	17.8	15.3	33.1	5.0
1982.....	22.1	14.3	36.4	5.5
1983.....	24.5	13.9	38.4	6.4
1984 (estimate).....	29.5	15.8	45.3	7.2
1985 (estimate).....	35.9	15.9	51.8	7.9

¹ Includes military-related R&D programs of the Departments of Defense and Energy.

² Included in totals for conduct of R&D.

SPECIAL ANALYSIS K

RESEARCH AND DEVELOPMENT

This analysis covers the funding of research and development across all agencies with R&D programs of \$10 million or more. These agencies fund over 99% of total Federal R&D.

In 1986, total Federal obligations for research and development, including R&D facilities, are estimated at \$60 billion, an increase of more than \$6 billion or 12 percent above the 1985 estimated level of \$53 billion as shown in Table K-1. Support for the conduct of basic research, included within this total, is estimated to increase by 1 percent, from \$7.8 billion in 1985 to \$7.9 billion in 1986.

Within the framework of necessary overall restraint to reduce the deficit the 1986 budget reflects the relatively high priority that this Administration gives to R&D that is appropriate for Federal support. It provides for:

- increases in R&D programs of the Department of Defense;
- a continued high level of support for basic research with further increases in several agencies, including the Department of Defense, the National Aeronautics and Space Administration, and the National Science Foundation. Emphasis continues to be given by several agencies (within basic research funding) to support for the acquisition of state-of-the-art instrumentation at universities and to providing better access to advanced computers by academic scientists; and,
- continued support for several major projects begun in 1985, including, for example, in the NSF, the Very Long Baseline Array radiotelescope; in NASA, the Mars Geoscience/Climatology Orbiter; and in the DOE budget, a new nuclear physics electron facility at Newport News, Virginia.

At the same time, the 1986 budget continues to propose reductions in programs that are not an appropriate Federal responsibility and should be left to the States or the private sector for appropriate investments. These include reductions in nearer-term technology development programs of the Department of Energy, selected programs of the Department of Commerce (e.g., the Sea Grant program), and research activities of the Department of Interior (e.g., the Mineral Institutes program).

Table K-1. TOTAL FEDERAL FUNDING FOR CONDUCT OF R&D AND RELATED FACILITIES

(In billions of dollars)

	Obligations			Outlays		
	1984 actual	1985 estimate	1986 estimate	1984 actual	1985 estimate	1986 estimate
Conduct of R&D	43.2	51.0	57.6	40.5	46.3	53.0
R&D facilities	1.9	2.2	2.1	1.6	2.1	2.0
Total	45.1	53.2	59.7	42.2	48.5	55.0

CONDUCT OF RESEARCH AND DEVELOPMENT

The budget for 1986 includes \$58 billion in obligations for the conduct of R&D, an increase of \$7 billion or 13 percent over 1985. Highlights of the proposed programs of the seven major R&D agencies, which account for over 90 percent of the obligations for the conduct of R&D by the Federal Government, are presented below.

- **Department of Defense (DOD).**—Obligations for the conduct of R&D by DOD are estimated at \$39.4 billion for 1986, an increase of \$7.1 billion or about 22 percent above 1985. The increased funds proposed for R&D are largely related to advances in tactical systems such as the JVX aircraft and the C-17 transport aircraft. In addition, DOD will increase its funding of basic research by about 16 percent, and also provide for an increased emphasis on the Strategic Defense Initiative.
- **Department of Energy (DOE).**—Obligations for the conduct of R&D programs in the Department of Energy are estimated at \$4.7 billion, a decrease of 2 percent from 1985. Included in this total, basic research funding in high energy and nuclear physics and in the basic engineering and energy sciences would be \$934 million, \$22 million higher than 1985. Within overall support for R&D, nuclear weapons R&D will increase from \$2,192 million to \$2,254 million, while funds for energy technology development programs are estimated to decrease from \$2,090 million to \$1,914 million. This decrease primarily reflects a continuing shift away from support for relatively costly nearer-term development and demonstration activities. The 1986 budget for basic research includes funds for accelerator R&D in support of the future construction of a new nuclear physics facility at Newport News, Virginia. Funds are also included to maintain the preliminary accelerator R&D efforts required for the design of a possible next generation high energy particle accelerator. In addition, the budget continues support for the research programs associated with ongoing construction projects such as the Center for Advanced Materials at the Lawrence Berkeley Laboratory and the accel-

erator upgrades at Fermilab and Brookhaven National Laboratory.

- **Department of Health and Human Services (HHS).**—The 1985 decision to restore stability to HHS R&D activities results in a number of research projects and research centers being funded for two years (through the end of 1986). As a consequence of this policy, in 1985 the National Institutes of Health (NIH), which accounts for about 90 percent of HHS R&D obligations, will fund 5,000 new and competing research project grants and 500 research centers. In 1986, the same number of research project grants and research centers will be supported. However, since some of these project grants and centers will have already received 1986 funding in 1985, total HHS R&D obligations will decrease by about 6 percent, from \$5.5 billion in 1985 to \$5.2 billion in 1986. This level represents an increase of almost 7 percent between 1984 and 1986.
- **National Aeronautics and Space Administration (NASA).**—Obligations for the conduct of R&D by NASA are estimated at \$3.7 billion in 1986, an increase of \$225 million over 1985. This will allow NASA to pursue work on a space station and continue programs in science, applications and in long-term advanced technology development for space projects and aeronautics. The 1986 budget continues the design and definition of a space station with development planned for the late 1980's and early 1990's. Initial operational capability is anticipated in the mid-1990's. For science programs, the budget provides for launch of both the Space Telescope and the Galileo mission to Jupiter in mid-1986. The budget also continues development of major flight projects including the Gamma Ray Observatory and the Mars Geoscience/Climatology Orbiter to map the Martian surface, the Upper Atmosphere Research Satellite, to investigate the chemistry of the Earth's upper atmosphere, and the Scatterometer, an instrument for a joint NASA-Navy mission to better understand global wind patterns. Other previously approved projects such as the Venus Radar Mapper and Spacelab experiments will be continued.
- **National Science Foundation (NSF).**—Obligations for research supported by NSF are expected to increase by about \$93 million, or 7 percent—to more than \$1.4 billion in 1986. The budget principally provides enhanced support for basic research in academic institutions through project grants with emphasis on the physical sciences and engineering and for university research instrumentation. The budget provides additional funds for the Engineering Research Centers program, initiated in 1985, aimed at strengthening multidisciplinary

research and training in engineering at universities, and for the Advanced Scientific Computing program to improve the productivity of U.S. scientists by providing them greater access to supercomputers.

- **Department of Agriculture (USDA).**—Obligations for the conduct of R&D are estimated at \$882 million for 1986, a decrease of 6 percent from the 1985 level of \$940 million. The proposed reduction reflects the need to control the growth of Federal spending. Within the USDA total, the Cooperative State Research Service will provide \$42 million to support research in biotechnology. Funding for the Competitive Grants program, which supports primarily basic agricultural research, is held at the 1985 level of \$46 million. The Agricultural Research Service expects to obligate \$485 million, slightly less than in 1985, for basic and applied research in soil and water conservation, plant and animal productivity and human nutrition. The Forest Service will enhance its research on land management planning and forest inventory. Other USDA research programs will focus on improving methods and techniques for obtaining agricultural statistics.
- **Department of Commerce (DOC).**—Obligations for R&D undertaken by DOC decrease by 29 percent between 1985 and 1986, from \$384 million to \$271. The proposed reductions reflect the Administration's continued efforts to reduce funding for programs that are more appropriately the responsibility of the private sector and State or local government. In addition to the Sea Grant Program of the National Oceanic and Atmospheric Administration, both the fire and building research programs at the National Bureau of Standards (NBS) will be eliminated. Some increases, however, are proposed for NBS in areas of growing importance, such as biotechnology, advanced quality control, ceramics and materials science. The budget also provides for construction of a Cold Neutron Research Facility at the Bureau, as well as increases for severe storm and air quality research.

Table K-2 summarizes Federal support for the conduct of R&D by agency.

CONDUCT OF BASIC RESEARCH

The 1986 budget continues this Administration's emphasis on the importance of support for basic research across all scientific disciplines even in a time of budget restraint. Scientific knowledge in fields such as mathematics, physics, chemistry, biology and the various engineering disciplines provides the foundation for the long-term achievement of national objectives of a strong defense, continued economic growth, and an enhanced quality of life.

Table K-2. CONDUCT OF RESEARCH AND DEVELOPMENT BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1984 actual	1985 estimate	1986 estimate	1984 actual	1985 estimate	1986 estimate
Defense-Military functions	26,408	32,318	39,426	23,583	28,539	34,860
Health and Human Services	4,836	5,472	5,159	4,449	4,995	5,239
(National Institutes of Health)	(4,252)	(4,835)	(4,561)	(3,960)	(4,408)	(4,654)
Energy	4,642	4,805	4,712	4,702	4,826	4,714
National Aeronautics and Space Administration..	2,877	3,506	3,730	3,539	3,260	3,564
National Science Foundation	1,203	1,354	1,447	1,108	1,313	1,403
Agriculture	868	940	882	867	901	882
Transportation	446	480	362	342	481	377
Interior	362	378	335	393	371	339
Environmental Protection Agency	261	312	327	266	282	317
Commerce	361	384	271	330	368	291
Agency for International Development	192	217	225	139	225	239
Veterans Administration	190	227	190	186	224	187
Nuclear Regulatory Commission	191	150	138	196	152	141
All other ¹	363	417	396	418	396	407
Total	43,199	50,958	57,598	40,518	46,331	52,958

¹ Includes the Departments of Education, Justice, Labor, Housing and Urban Development and Treasury, the Tennessee Valley Authority, the Smithsonian Institution, the Corps of Engineers, and the Federal Emergency Management Agency.

Funding for basic research is included within the overall Federal support for the conduct of R&D. In 1986, obligations for the conduct of basic research are estimated at \$7.9 billion, an increase of \$76 million, or 1 percent above the level for 1985.

Within this total, support for basic research in the physical sciences and engineering will increase in 1986 by about 7 percent, with the largest increases occurring in the DOD, NSF and NASA.

Funding for basic research by agencies principally supporting the life and other sciences will decrease 5 percent. The decrease is principally attributable to NIH, which is changing its method of funding some project grants and research centers, as discussed above. Support for basic research in the life and other sciences has increased by more than 8 percent since 1984 and by almost 50 percent since 1982.

Support of basic research particularly serves to strengthen the ability of the Nation's academic research scientists to conduct high-quality research and to educate the next generation of scientists and engineers. University-based researchers receive about half of the total Federal obligations for basic research and provide the critical element of education to maintain a vigorous, first-class scientific and technical talent pool.

Table K-3 summarizes Federal support for the conduct of basic research by agency.

Table K-3. CONDUCT OF BASIC RESEARCH BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars) ¹

Department or agency	Obligations			Outlays		
	1984 actual	1985 estimate	1986 estimate	1984 actual	1985 estimate	1986 estimate
Agencies supporting primarily physical sciences and engineering: ²						
National Science Foundation.....	1,132	1,273	1,366	1,042	1,235	1,325
Defense—Military functions.....	847	829	962	720	768	852
Energy.....	827	912	934	820	904	937
National Aeronautics and Space Administration.....	713	801	834	729	825	818
Interior.....	120	130	119	133	128	120
Commerce.....	21	22	18	21	21	18
Other Agencies ³	9	9	10	8	9	10
Subtotal.....	3,668	3,976	4,241	3,473	3,891	4,078
Agencies supporting primarily life and other sciences: ⁴						
Health and Human Services.....	2,812	3,225	3,049	2,587	2,938	3,087
(National Institutes of Health).....	(2,625)	(3,022)	(2,847)	(2,441)	(2,753)	(2,896)
Agriculture.....	393	440	418	394	410	407
Smithsonian Institution.....	61	65	64	56	63	66
Environmental Protection Agency.....	30	37	40	26	24	28
Veterans Administration.....	16	15	16	16	16	16
Education.....	10	12	12	28	9	11
Other Agencies ⁵	16	17	22	14	17	19
Subtotal.....	3,337	3,810	3,621	3,120	3,476	3,633
Total.....	7,005	7,786	7,862	6,593	7,367	7,712

¹ Amounts reported in this table are included in totals for conduct of R&D.² Includes mathematics and computer sciences.³ Includes the Corps of Engineers, the Federal Emergency Management Agency, the Tennessee Valley Authority, and the Department of Transportation.⁴ Includes psychology and social sciences.⁵ Includes the Departments of Labor, Justice, and Treasury, and the Agency for International Development.

R&D FACILITIES

In 1986, within the total for support for R&D facilities, funding is provided for major scientific instrumentation, including the specialized research facilities at national laboratories and university centers e.g., particle accelerators, telescopes, and advanced computers. Such specialized facilities are critical to advancing the frontiers of science in a number of scientific disciplines. Funds for R&D facilities are also used for construction or renovation of general purpose laboratories and research support facilities.

In 1986, obligations for R&D facilities are expected to total \$2.1 billion, a decrease of \$162 million from 1985. The decrease primarily reflects completion of several major construction projects in DOE including the Tevatron I accelerator at Fermilab, and university accelerator upgrades at the University of Washington and Yale University. In keeping with the need for budgetary restraint, no major new construction projects will begin in 1986.

Table K-4 summarizes Federal support for R&D facilities and capital equipment.

Table K-4. RESEARCH AND DEVELOPMENT FACILITIES BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1984 actual	1985 estimate	1986 estimate	1984 actual	1985 estimate	1986 estimate
Energy.....	921	1,167	1,014	909	1,211	1,104
Defense—Military functions.....	532	589	556	383	469	446
National Aeronautics and Space Administration..	238	275	244	192	248	241
Agriculture.....	39	48	95	29	52	96
National Science Foundation.....	45	65	71	43	63	69
Health and Human Services.....	32	55	39	35	43	36
(National Institutes of Health).....	(28)	(35)	(28)	(21)	(33)	(24)
All other ¹	46	39	56	43	46	37
Total.....	1,853	2,237	2,075	1,633	2,131	2,030

¹ Includes the Departments of Transportation, Commerce, Interior, and Treasury, the Agency for International Development, Veterans Administration, Tennessee Valley Authority, and the Smithsonian Institution.

Table K-5 provides information on the long-term trends in Federal funding for the conduct of R&D.

Table K-5. TRENDS IN CONDUCT OF R&D

(Obligations in billions of dollars)

Year	Defense ¹	All other	Total	Basic research ²
1960.....	6.1	1.5	7.6	0.6
1961.....	7.0	2.1	9.1	0.8
1962.....	7.2	3.1	10.3	1.0
1963.....	7.8	4.7	12.5	1.2
1964.....	7.8	6.4	14.2	1.3
1965.....	7.3	7.3	14.6	1.4
1966.....	7.5	7.8	15.3	1.6
1967.....	8.6	7.9	16.5	1.8
1968.....	8.3	7.6	15.9	1.8
1969.....	8.4	7.2	15.6	1.9
1970.....	8.0	7.3	15.3	1.9
1971.....	8.1	7.4	15.5	2.0
1972.....	8.9	7.6	16.5	2.2
1973.....	9.0	7.8	16.8	2.2
1974.....	9.0	8.4	17.4	2.4
1975.....	9.7	9.3	19.0	2.6
1976.....	10.4	10.4	20.8	2.8
1977.....	11.9	11.6	23.5	3.3
1978.....	12.6	13.2	25.8	3.7
1979.....	13.6	14.5	28.1	4.2
1980.....	15.1	14.7	29.8	4.7
1981.....	17.8	15.3	33.1	5.0
1982.....	22.1	14.3	36.4	5.5
1983.....	24.5	13.9	38.4	6.4
1984.....	28.3	14.9	43.2	7.0
1985 (estimate).....	34.5	16.5	51.0	7.8
1986 (estimate).....	41.7	15.9	57.6	7.9

¹ Includes military-related programs of the Departments of Defense and Energy.

² Included in totals for conduct of R&D.

SPECIAL ANALYSIS K

RESEARCH AND DEVELOPMENT

This analysis covers the funding of research and development across all agencies with R&D programs of \$10 million or more. It consists of two sections. The first highlights the R&D policies and trends in the 1987 budget. The second describes in more detail the R&D programs of 12 agencies whose R&D obligations individually exceed \$150 million. These agencies fund over 99 percent of total Federal R&D.

PART I. HIGHLIGHTS

In 1987, total Federal obligations for research and development, including R&D facilities, are estimated at \$63 billion, an increase of almost \$9 billion or 16 percent above the 1986 estimated level of \$54 billion as shown in table K-1. Support for the conduct of basic research, included within this total, is estimated to increase by 8 percent, from \$8.0 billion in 1986 to \$8.6 billion in 1987.

All of the 1986 estimates reflect the reductions mandated by the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings). These reductions generally reduced 1986 appropriated amounts for R&D by over 4% in the case of civilian programs and about 5% in the case of defense activities.

Within the framework of necessary overall restraint to reduce the deficit, the 1987 budget reflects the continued high priority that this Administration gives to R&D that is appropriate for Federal support. It provides significant increases for:

- the R&D programs of the Department of Defense, including the Strategic Defense Initiative and the nuclear weapons R&D program of the Department of Energy;
- the R&D programs of the National Aeronautics and Space Administration, primarily related to initiation of Space Station Development; and
- government-wide support of basic research, particularly through programs of the National Aeronautics and Space Administration, the Department of Energy, and the National Science Foundation.

At the same time, the 1987 budget continues to propose reductions in programs that are not an appropriate Federal responsibility and should be left to the states or the private sector for needed investments. These include large reductions across the energy tech-

nology programs of the Department of Energy, as well as elimination of selected programs of the Department of Commerce (e.g., the Sea Grant program), and research activities of the Department of Interior (e.g., the Mineral Institutes program).

Table K-1. TOTAL FEDERAL FUNDING FOR CONDUCT OF R&D AND RELATED FACILITIES

(In billions of dollars)

	Obligations			Outlays		
	1985 actual	1986 estimate	1987 estimate	1985 actual	1986 estimate	1987 estimate
Conduct of R&D	49.5	52.0	60.8	45.2	47.8	51.4
R&D facilities	1.9	1.8	1.7	1.8	1.7	1.7
Total	51.4	53.8	62.5	47.0	49.5	53.1

CONDUCT OF RESEARCH AND DEVELOPMENT

The budget for 1987 includes \$61 billion in obligations for the conduct of R&D, an increase of \$9 billion or 17 percent over 1986. Highlights of the proposed programs of the seven major R&D agencies, which account for over 97 percent of the obligations for the conduct of R&D by the Federal Government, are presented below.

- **Department of Defense (DOD).**—Obligations for the conduct of R&D by DOD are estimated at \$41.8 billion for 1987, an increase of \$8.3 billion or about 25 percent above 1986. The increased funds proposed for R&D allow growth for several important programs, including work on the Strategic Defense Initiative, the development of the C-17 transport aircraft, and a joint NASA-DOD program to explore technology development on advanced concepts for a future transatmospheric vehicle.
- **Department of Energy (DOE).**—Obligations for the conduct of R&D by the Department of Energy are estimated at \$4.9 billion, a net increase of 2 percent over 1986. Significant increases in nuclear weapons R&D and in basic research are offset by major reductions in energy technology programs. Nuclear weapons R&D will increase from \$2,246 million to \$2,609 million. Funding for the General Sciences program, which includes basic research in high energy and nuclear physics, will increase to \$602 million in 1987. Included in this total are funds for construction of a new nuclear physics facility at Newport News, Virginia and to continue construction projects such as the Accumulator/Booster Ring at the Brookhaven Alternating Gradient Synchrotron. Obligations for Energy Programs will decrease from \$2.0 billion in 1986 to \$1.7 billion in 1987. Within this total, significant increases for basic energy research will be more than offset by reductions

in applied research and development related to specific energy technologies.

- **Department of Health and Human Services (HHS).**—The Administration continues to fund HHS R&D activities at stable and sustainable levels. In 1987, the National Institutes of Health (NIH) will support 18,000 research projects grants, 523 research centers, and 9,100 research trainees. In addition, the Administration's Fair Share Allocated Overhead policy will reimburse research institutions for their administrative expenses at reasonable and fair rates, and will provide additional resources to support high-priority, high-quality research. In 1987, total HHS obligations will amount to almost \$5.5 billion.
- **National Aeronautics and Space Administration (NASA).**—NASA obligations for the conduct of R&D including facilities are estimated at \$4.4 billion in 1987, an increase of \$510 million over 1986. Much or most of this increase initiates space station development planned to be continued in the late 1980's and early 1990's. Initial operational capability is anticipated in the mid-1990's. For science programs, the budget continues support for the Space Telescope and the Galileo mission to Jupiter. The budget also continues development of major flight projects such as the Gamma Ray Observatory and the Mars Observer Mission. It provides for one new mission in 1987, the Ocean Topography Mission (TOPEX), and for instrument development for the International Solar-Terrestrial Physics (ISTP) program.
- **National Science Foundation (NSF).**—Obligations for research supported by NSF are expected to increase by about \$174 million, or 13 percent—to \$1.5 billion in 1987. The budget principally provides enhanced support for basic research in academic institutions with emphasis on the physical sciences and engineering, and on providing modern research instrumentation in universities. The budget provides additional funds for the Engineering Research Centers program, initiated in 1985, aimed at strengthening multidisciplinary research and training in engineering at universities, and for the Advanced Scientific Computing program to improve the productivity of U.S. scientists by providing them greater access to supercomputers. The budget also provides increased support for high-priority research in the geosciences, computational science and engineering, and in biotechnology.
- **Department of Agriculture (USDA).**—Obligations for the conduct of R&D are estimated at \$907 million for 1987, a decrease of 2 percent from the 1986 level of \$922 million. Within the USDA total, the Cooperative State Research Service will

provide \$234 million for research and development primarily conducted by colleges and universities. The Agricultural Research Service expects to obligate \$497 million, an increase of \$34 million over 1986, with emphasis on basic research in plant germplasm, biotechnology, new agricultural products, and the improvement of commodity exports. The Forest Service will continue its research on land management planning and forest inventory.

- **Department of Commerce (DOC).**—Obligations for R&D undertaken by DOC decrease by \$83 million between 1986 and 1987, to \$297 million. The proposed reductions reflect the Administration's continued efforts to reduce funding for programs that are more appropriately the responsibility of the private sector and state or local governments. Programs proposed for elimination include the Sea Grant Program of the National Oceanic and Atmospheric Administration, and both the fire and building research programs at the National Bureau of Standards (NBS). Some increases, however, are proposed for NBS in areas of growing importance, such as ceramics and optical fiber systems. The budget also provides for construction of a Cold Neutron Research Facility at the Bureau.

Table K-2 summarizes Federal support for the conduct of R&D by agency.

Table K-2. CONDUCT OF RESEARCH AND DEVELOPMENT BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1985 actual	1986 estimate	1987 estimate	1985 actual	1986 estimate	1987 estimate
Defense-Military functions	31,099	33,485	41,823	27,878	29,267	32,693
Health and Human Services	5,444	5,524	5,471	4,997	5,561	5,532
(National Institutes of Health)	(4,824)	(4,905)	(4,672)	(4,419)	(4,957)	(4,752)
Energy	4,901	4,785	4,886	4,900	4,778	4,819
National Aeronautics and Space Administration..	3,235	3,594	4,051	2,970	3,528	3,743
National Science Foundation	1,346	1,334	1,508	1,186	1,338	1,455
Agriculture	941	922	907	889	913	911
Transportation	430	364	277	417	416	331
Interior	389	381	345	414	403	351
Environmental Protection Agency	320	334	310	275	318	332
Commerce	399	380	297	373	383	311
Agency for International Development	210	206	203	204	208	209
Veterans Administration	227	186	194	215	182	187
All other ¹	550	531	531	527	538	544
Total	49,491	52,024	60,803	45,244	47,832	51,418

¹ Includes the Departments of Education, Justice, Labor, Housing and Urban Development and Treasury, the Tennessee Valley Authority, the Smithsonian Institution, the Corps of Engineers, the Nuclear Regulatory Agency, and the Federal Emergency Management Agency.

CONDUCT OF BASIC RESEARCH

The 1987 budget continues this Administration's emphasis on the importance of increased support for basic research across all scientific disciplines. Even in a time of budget restraint, such support represents an essential investment in the nation's future. Scientific knowledge in fields such as mathematics, physics, chemistry, biology and the various engineering disciplines provides the foundation for long-term achievement of national objectives of a strong defense, continued economic growth, and an enhanced quality of life.

Funding for basic research is included within the overall Federal support for the conduct of R&D. In 1987, obligations for the conduct of basic research are estimated at \$8.6 billion, an increase of \$614 million, or 8 percent above the level for 1986.

Support of basic research particularly serves to strengthen the ability of the nation's academic research scientists to conduct high-quality research and to assist in educating the next generation of scientists and engineers. University-based researchers receive about half of the total Federal obligations for basic research and provide the critical element of education to maintain a vigorous, first-class scientific and technical talent pool.

Table K-3 summarizes Federal support for the conduct of basic research by agency.

ARCTIC RESEARCH

Two complementary policy documents currently govern U.S. Arctic research policy. The Arctic Research and Policy Act of 1984 (Public Law 98-373) requires an ". . . integrated, coherent, and multiagency request . . ." for research in the Arctic as part of the President's annual budget request to Congress. National Security Decision Directive 90 (NSDD 90, April 14, 1983) identifies four basic elements of U.S. Arctic Policy:

- protection of essential security interests in the arctic region, including the adjacent seas and airspace;
- support for sound, rational development in the arctic region, while minimizing adverse effects on the environment;
- promotion of scientific research in fields which contribute knowledge about the Arctic, or which are most advantageously studied in the Arctic; and,
- promotion of mutually beneficial international cooperation in the Arctic to achieve the above objectives.

In response to these directives, the Interagency Arctic Research Policy Committee (established by Public Law 98-373) has compiled a detailed listing of agency programs in arctic research, including budgetary estimates, and has grouped them into three major categories of national concern:

- national security;

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THE BUDGET FOR FISCAL YEAR 1987

Table K-3. CONDUCT OF BASIC RESEARCH BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars) ¹

Department or agency	Obligations			Outlays		
	1985 actual	1986 estimate	1987 estimate	1985 actual	1986 estimate	1987 estimate
Agencies supporting primarily physical sciences and engineering: ²						
National Science Foundation.....	1,262	1,256	1,423	1,111	1,260	1,372
Defense—Military functions.....	860	940	987	705	834	759
Energy.....	926	922	1,045	896	907	1,018
National Aeronautics and Space Administration.....	728	857	1,085	704	870	1,018
Interior.....	131	132	118	142	145	121
Commerce.....	23	22	20	23	21	20
Other Agencies ³	12	13	11	11	14	13
Subtotal.....	3,942	4,142	4,688	3,592	4,051	4,321
Agencies supporting primarily life and other sciences: ⁴						
Health and Human Services.....	3,229	3,290	3,353	2,954	3,303	3,381
(National Institutes of Health).....	(3,024)	(3,077)	(2,938)	(2,765)	(3,099)	(2,988)
Agriculture.....	447	434	434	406	423	427
Smithsonian Institution.....	71	71	79	61	66	73
Environmental Protection Agency.....	39	39	37	25	36	38
Veterans Administration.....	15	15	16	16	15	15
Education.....	12	11	10	6	6	11
Other Agencies ⁵	15	15	14	15	16	14
Subtotal.....	3,828	3,875	3,942	3,483	3,865	3,958
Total.....	7,769	8,017	8,630	7,076	7,915	8,279

¹ Amounts reported in this table are included in totals for conduct of R&D.² Includes mathematics and computer sciences.³ Includes the Corps of Engineers, the Federal Emergency Management Agency, the Tennessee Valley Authority, and the Department of Transportation.⁴ Includes psychology and social sciences.⁵ Includes the Departments of Labor, Justice, and Treasury, and the Agency for International Development.

- rational development with minimal environmental or adverse social impact; and,
- research on arctic phenomena and on science best studied in the Arctic (the Arctic as a natural laboratory).

Table K-4 provides a summary of Federal support for arctic research integrated by major category.

Table K-4. FEDERAL SUPPORT FOR ARCTIC RESEARCH ¹

(Obligations in millions of dollars)

Category	1985 actual	1986 estimate	1987 estimate
National security.....	22,624	26,125	26,278
Rational development.....	35,049	34,974	34,457
Natural laboratory.....	21,163	21,929	22,036
Total.....	78,836	83,028	82,771

¹ Includes the Departments of Defense, Energy, Health and Human Services, Interior, Commerce, and Transportation, the National Science Foundation, the National Aeronautics and Space Administration, the Environmental Protection Agency and the Smithsonian Institution.

R&D FACILITIES

In 1987, within the total for support for R&D facilities, funding is provided for major scientific instrumentation, including the specialized research facilities at national laboratories and university centers, e.g., particle accelerators, telescopes, and advanced computers. Such specialized facilities are critical to advancing the frontiers of science in a number of scientific disciplines. Funds for R&D facilities are also used for construction or renovation of general purpose laboratories and research support facilities.

In 1987, obligations for R&D facilities are expected to total \$1.7 billion, a decrease of \$78 million from 1986. Even though total funding will decrease in 1987, the budget still provides for initiation of several major new construction projects in DOE, including an advanced nuclear physics facility at Newport News, Virginia and the 1-2 GeV synchrotron source at Lawrence Berkeley Laboratory.

Table K-5 summarizes Federal support for R&D facilities and capital equipment.

Table K-5. RESEARCH AND DEVELOPMENT FACILITIES BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1985 actual	1986 estimate	1987 estimate	1985 actual	1986 estimate	1987 estimate
Energy.....	909	813	759	958	902	826
Defense—Military functions.....	533	437	453	404	325	376
National Aeronautics and Space Administration..	268	279	332	247	271	310
Agriculture.....	41	92	42	34	48	69
National Science Foundation.....	74	68	84	64	68	81
Health and Human Services.....	43	54	10	43	46	27
(National Institutes of Health).....	(29)	(44)	(8)	(26)	(35)	(19)
All other ¹	27	68	54	34	30	41
Total.....	1,894	1,812	1,734	1,784	1,690	1,730

¹ Includes the Departments of Transportation, Commerce, Interior, and Treasury, Veterans Administration, Tennessee Valley Authority, and the Smithsonian Institution.

PART II. AGENCY R&D PROGRAMS

Presented below are summaries of the R&D activities of the 12 agencies whose R&D obligations individually exceed \$150 million.

DEPARTMENT OF DEFENSE

DOD research and development is oriented toward the development of strategic and tactical weapons and supporting systems to provide for the nation's defense.

DOD obligations for the conduct of R&D in 1987 will total \$41.8 billion, an increase of \$8.3 billion over 1986. Within the total, funding for basic research will increase from \$940 million in 1986

to \$987 million in 1987. R&D facilities funding would total \$453 million, up from \$437 million in 1986.

By mission category, major R&D efforts for 1987 include:

- Technology Base and Advanced Technology Development.*—The purpose of these programs is to investigate promising new technologies and to avoid technological surprise by potential adversaries. Funding (budget authority) for the Strategic Defense Initiative (SDI) will increase from \$2.8 billion in 1986 to \$4.8 billion in 1987. SDI areas of study include sensors, laser weapons, high-speed missiles, battle management computers and systems designs. The DOD University Research Initiative program will continue with \$50 million set aside in 1987 to support selected technology thrusts (including instrumentation) at the nation's universities. These funds augment other funds used to support specific research programs at universities. A joint NASA-DOD technology development program would be started to explore advanced concepts for a future transatmospheric vehicle.
- Strategic Programs.*—Programs receiving emphasis in 1987 include the MILSTAR communications satellite program, the Small Intercontinental Ballistic Missile, a short range air-launched attack missile, the Peacekeeper missile and Stealth development. B-1B bomber development winds down as the aircraft enters deployment.
- Tactical Programs.*—Systems are developed to improve the capability of U.S. general purpose and theater nuclear forces, and allow the rapid deployment of those forces wherever the vital interests of the United States are threatened.
 - The Army is developing upgrades to its combat vehicles, the Patriot air defense missile system, aircraft engines and field artillery. In addition, an advanced anti-tank weapon and a light helicopter are being developed.
 - The Navy is developing a new attack submarine. The P-3 antisubmarine patrol aircraft will be upgraded, and development of the V-22 tilt-rotor aircraft, the T-45/TS trainer aircraft, the F-14 upgrade, and the A-6E attack aircraft improvement program will continue.
 - The Air Force continues work on the Advanced Tactical Fighter aircraft, improvements to the F-15 and F-16 aircraft, and the Airborne Warning and Control System (AWACS). The Alternate Fighter Engine program seeks improvements to fighter aircraft engine reliability. The C-17 transport aircraft development progresses.
- Intelligence and Communications, Program Management and Support.*—R&D on intelligence and communication systems will focus on communication satellites, on radios that will

work in the electronic noise of the battlefield, and on surveillance radars. Work will also continue on the use of technology to reduce manufacturing costs and to extend the life and capability of existing defense systems.

—*NATO Cooperation.*—Cooperation in research and development and joint production of new weapon systems will be pursued to make the best use of Alliance resources. Funding for these activities is not identified separately in table K-6 but is included in the other categories listed in that table.

Table K-6 provides the details of the Department of Defense military R&D funding.

Table K-6. DEPARTMENT OF DEFENSE—MILITARY RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity	1985 actual	1986 estimate	1987 estimate
OBLIGATIONS			
Conduct of R&D:			
Research, development, test and evaluation:			
Technology base.....	3,149	3,179	3,596
Advanced technology development.....	2,754	3,949	6,312
Strategic programs.....	7,983	7,251	9,120
Tactical programs.....	8,857	10,179	12,446
Intelligence and communications.....	3,942	4,368	5,028
Program management and support.....	3,350	3,484	4,199
Other appropriations.....	1,064	1,075	1,122
Total conduct of R&D ¹	31,099	33,485	41,823
Total conduct of basic research, included above.....	(860)	(940)	(987)
R&D facilities.....	533	437	453
Total obligations.....	31,632	33,922	42,275
OUTLAYS			
Conduct of R&D.....	27,878	29,267	32,693
R&D facilities.....	404	325	376
Total outlays.....	28,282	29,592	33,070

¹ Includes funds for Operational Systems Development of \$7,883 million in 1985, \$8,636 million in 1986 and \$10,630 million in 1987.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA makes investments in R&D programs to provide for a permanent U.S. presence in space with a future space station; to maintain the Shuttle-based Space Transportation System; to advance knowledge of the Earth, the near-Earth environment, the solar system and the universe; and to support long-term research and technology advancement for low gravity materials science and satellite communications. It also supports long-term research and selected systems technology projects in aeronautics.

R&D accounts for about two-fifths of the total budget for NASA. The balance of the NASA budget includes funding primarily for

Shuttle production and operations, tracking and data acquisition activities, and related institutional support.

In 1987, NASA obligations for R&D including facilities for the agency will be approximately \$4.4 billion, a net increase of \$510 million over 1986. Within this total, funds are available to complete projects currently under development, to augment major research and technology programs, and to initiate a major new flight project in space science and applications. Within the total funding for R&D, basic research obligations in 1987 are estimated at \$1.1 billion, an increase of \$228 million, or 27 percent over 1986. Within the total of \$332 million in 1987 for R&D facilities, a decrease in obligations for facilities construction will be more than offset by an increase for the acquisition of capital equipment.

Space transportation.—Obligations for Space Transportation R&D are estimated to increase from \$611 million in 1986 to \$817 million in 1987. This increase is consistent with funding needed to pursue design, definition, and development of the space station for planned launch in the early 1990's.

The space station is intended to enhance the nation's science and applications programs, to help develop advanced technologies potentially useful to the economy, and to encourage greater commercial use of space.

The 1987 budget provides for restoring progress in the Space Shuttle program towards achieving routine and reliable access to space for all planned users, and for continued investments to further improve the reliability and performance of the Shuttle fleet. Other major continuing activities in the 1987 budget will include development and procurement of the Centaur upper stage—a new high-energy upper stage for use with the Shuttle; further development of the tethered satellite program, a Shuttle-based science program conducted in cooperation with the Italian government; and development of an Orbital Maneuvering Vehicle for future near-Earth orbital transfers.

Space science and applications.—Obligations for space science and applications are estimated in 1987 at \$1.6 billion, essentially at the 1986 level. The funding provided will allow initiation of a major new flight project, continued support of ongoing flight projects, and the analysis of scientific data being sent back to Earth from spacecraft now in space.

The 1987 budget continues support for space science research to enhance understanding of the Sun, the planets, and the universe; space-related research on the Earth's climate, resources, surface and atmosphere; research to advance knowledge in materials science and materials processing through low gravity experiments in space; and continuing long-term basic technology work for satellite communications.

The major new flight project proposed for initiation in 1987 is an Ocean Topography Experiment (TOPEX), a joint U.S.-French cooperative project, to measure the surface topography of the oceans over three years to help determine the oceans' general circulation. In addition, NASA will undertake instrument development for the International Solar-Terrestrial Physics (ISTP) program. This program, which would be planned and carried out jointly by the U.S., the European Space Agency (ESA), and Japan, is intended to provide a comprehensive effort to measure phenomena associated with the Sun-Earth interaction chain.

Continuing development efforts for ongoing major flight projects yet to be launched include:

- the Gamma Ray Observatory, planned for launch in 1988, which will enhance basic research in high energy astrophysics, providing new knowledge about objects in deep space;
- Spacelab astronomy experiments, which will be conducted on the Shuttle with the goal of improving our understanding of the Earth's vicinity, the Sun and the universe;
- the Magellan project, planned for launch in 1988, to map the planet Venus;
- the Mars Observer Mission, a major Space Science project planned for 1990 launch, to continue the scientific exploration of the planet Mars;
- the Upper Atmosphere Research Satellite (UARS) spacecraft, to be launched in 1989, to investigate the chemical composition of the Earth's stratosphere and mesosphere; and
- the Scatterometer project, a research instrument to measure global wind patterns on the surface of the oceans. This instrument will be flown in 1990 on a Navy satellite now under development.

Continued support will be provided in 1987 for several satellites, including:

- two Voyager spacecraft, launched in 1977, which have successfully encountered Jupiter and Saturn; Voyager 2 encountered Uranus in January 1986 and is scheduled to fly by Neptune in 1989;
- the Galileo orbiter and probe mission to Jupiter to carry out long-term studies of the planet, its satellites, and its magnetosphere; and
- the Space Telescope, which is expected to serve as a major astronomy facility for a 10- to 15-year period.

The budget also provides for continuing research and technology work in areas such as space-related life science research; near-Earth experiments using balloons and sounding rockets; research in geodynamics, ocean processes, and atmospheric dynamics; Shut-

tle-based science and applications experiments; and preparations for the future launch of planned missions. Continuing efforts to improve satellite communications technology will be refocused towards generic and longer-term technology-based efforts, in recognition of the responsibility of the private sector to pursue relatively near-term satellite communications technologies.

Transatmospheric research and technology.—In 1987, a new program, supported jointly by DOD and NASA, in transatmospheric research and technology will be initiated. This activity will encompass a vigorous program of research and advanced technology in areas such as airbreathing propulsion, high-temperature structures and advanced materials, and is expected to lead to a transatmospheric flight research vehicle demonstration phase in the early 1990s.

Aeronautical research and technology.—Obligations for aeronautical research and technology are estimated to increase from \$274 million to \$334 million in the 1987 budget to augment ongoing research in fundamental aeronautical disciplines such as materials and structures, propulsion and selected systems technology projects.

In 1987, increased funds are included to continue the following ongoing efforts:

- the X-wing rotorcraft project, a joint NASA/DOD project to develop the technology for future high speed rotorcraft using the X-wing rotor concept; and
- numerical aerodynamic simulation (NAS), which will allow greater use of advanced computational techniques to improve the productivity of aeronautical research and design. In 1987, the NAS system will begin its first year of full operational capability.

Agency-wide support activities.—Obligations for agency-wide support activities will total \$1.2 billion in 1987, a slight increase above the 1986 level. These programs include primarily R&D-related NASA civil service and administrative costs, tracking and data acquisition system improvements, and R&D addressing fundamental space technology problems and opportunities common to a wide spectrum of space programs.

Table K-7 provides the details of NASA's R&D funding.

DEPARTMENT OF ENERGY

The R&D programs of the Department of Energy include: a *National Defense Program* related to the development and testing of nuclear weapons; a *General Science Program* of basic research in high energy physics and nuclear sciences; and an *Energy Program* on R&D in support of energy technology development. Table K-8 provides summary information on the funding of these programs.

Table K-7. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity	1985 actual	1986 estimate	1987 estimate
OBLIGATIONS			
Conduct of R&D:			
Space transportation systems.....	505	611	817
Space science and applications.....	1,341	1,564	1,571
Transatmospheric research and technology.....			43
Aeronautical research and technology.....	312	274	334
Agency-wide support activities:			
Space research and technology.....	127	171	180
Tracking and data acquisition.....	15	16	18
Research and program management.....	935	958	1,088
Total conduct of R&D.....	3,235	3,954	4,051
Total conduct of basic research, included above.....	(728)	(857)	(1,085)
R&D facilities.....	268	279	332
Total obligations.....	3,503	3,873	4,383
OUTLAYS			
Conduct of R&D.....	2,970	3,528	3,743
R&D facilities.....	247	271	310
Total outlays.....	3,217	3,799	4,052

Obligations for the conduct of R&D by the Department are estimated to total \$4.9 billion in 1987, an increase of \$100 million from 1986. Obligations in 1987 for R&D facilities, including the construction or upgrading of general purpose laboratories and other research support facilities, will amount to \$759 million.

Obligations for the conduct of basic research, included in the total for the conduct of R&D, are estimated to be \$1,045 million in 1987, an increase of \$120 million over 1986. Within the basic research total, funds are provided to continue or initiate a number of major projects, in both the energy program and the general science program, that will enhance the nation's capability in basic research.

The *National Defense Program* supports the continued research, development and testing of nuclear weapons. It also supports the development of improved naval propulsion reactors, technologies for monitoring nuclear weapons treaties, and methods for safeguarding nuclear materials. In addition, R&D efforts will continue in developing methods for the safe storage and disposal of radioactive wastes resulting from weapons production. Obligations for the national defense program for the conduct of R&D will increase from \$2.2 billion in 1986 to \$2.6 billion in 1987. Increased funding for conduct of R&D provides for continued R&D in isotope separation techniques, for increased weapons testing, and for increased research in the basic physics of nuclear weapons. Increases in the

advanced weapons concepts activities will focus on research in support of the Strategic Defense Initiative.

The *General Science Program* supports basic research in high energy and nuclear physics. A proposed increase of \$88 million, to \$602 million, in 1987 will enhance support for experimental efforts to understand the basic constituents of matter and energy and the forces that govern their interaction.

The 1987 budget request will provide for:

- increased utilization of existing accelerator facilities, including operation of the newly-completed (1986) Tevatron I upgrade at Fermilab and the Stanford Linear Collider at SLAC;
- initiation of a heavy ion nuclear research and accelerator program at the Brookhaven Alternating Gradient Synchrotron;
- completion of the LAMPF proton beam facilities upgrade at the Los Alamos National Laboratory;
- continued construction of the Central Computing Facility project at Fermilab and the Accumulator/Booster Ring upgrade at the Brookhaven Alternating Gradient Synchrotron; and
- initiation of the construction phase of an advanced nuclear physics electron accelerator facility at Newport News, Virginia.

The budget also includes funds for continued advanced accelerator and detector research and development activities related to the next-generation high-energy particle physics accelerator.

The *Energy Program* funds basic science and engineering research underlying both nuclear and non-nuclear technologies, R&D to support development of specific energy technologies, and research on the environmental and human health effects of energy production technologies. Energy program obligations for the conduct of R&D will decrease from \$2.0 billion in 1986 to \$1.7 billion in 1987. Obligations for R&D facilities in this program will be \$125 million, a decrease of \$88 million from 1986.

In the *basic energy sciences*, funding is proposed at a level of \$441 million in 1987, a slight increase over 1986, for research in such fields as nuclear science, chemistry, engineering, materials science, applied mathematics, biology, and the geosciences. The program provides the fundamental scientific and technical base for future advances in both nuclear and non-nuclear technology development. In addition, the program provides support for the operation of several major national facilities that are used by researchers from industry, universities and national laboratories. These include the National Synchrotron Light Source (NSLS) at the Brookhaven National Laboratory, the Intense Pulsed Neutron Source (IPNS) facility at Argonne National Laboratory, and the Electromagnetic Iso-

tope Separation Plant (Calutrons) at Oak Ridge National Laboratory.

The 1987 budget continues to provide support for construction of the Center for Advanced Materials at Lawrence Berkeley Laboratory (LBL), the Ion Collision Physics Facility at Kansas State University, the expansion of NSLS, the upgrade of the Stanford Synchrotron Radiation Laboratory facilities, and the experimental guide-hall for the Los Alamos Neutron Scattering Center.

The budget also provides funds for initiation of construction of a 1-2 GeV synchrotron at LBL and for R&D activities related to advanced synchrotron and neutron facilities required for future engineering and science research.

A new *clean coal technology* program, mandated by Congress in the 1986 budget, has been added to the *Energy Program*. This activity has a budget authority of \$398 million in 1986 to be obligated over a three-year period. The Department will solicit proposals from the private sector for cost-shared commercial-scale demonstrations of clean coal technologies. Typical examples of such technologies include: advanced coal cleaning techniques, alternate combustion technologies, preparation of clean coal based fuels, and post-combustion cleanup systems.

The 1987 budget will continue the redirection of the on-going non-nuclear R&D programs to limit federal support to longer-term generic research and place greater reliance on the private sector for support of nearer-term technology development. To increase the involvement of the private sector in the direction and management of industry-based R&D programs, funds will be available in 1987 to support DOE participation in industry-cooperative R&D ventures in broad areas of generic technology development. Obligations for the conduct of R&D in the *fossil, solar/renewables* and *conservation* programs are expected to be \$273 million in 1987, a decrease of about \$320 million from 1986.

Funding for the conduct of *fossil* related R&D and associated facilities will be \$150 million in 1987, a decrease of \$163 million from 1986. The 1987 budget is focused on research to improve technologies for utilizing coal and for extracting oil and gas from unconventional sources. Support in the technology base program continues to be provided in such areas as the chemistry of coal conversion, environmental controls, and combustion research. Major themes of the cooperative research program will be coal preparation and utilization technology, oil and gas extraction processes, and alternate (coal-based) fuels development.

Research in support of *solar and other renewable energy* technologies, proposed at a level of \$108 million, will emphasize longer term, technology base R&D in areas such as photovoltaics, solar thermal energy, biofuels, wind and geothermal energy, electrical

energy systems, and energy storage. The total request for the *energy conservation* R&D program is \$71 million. Research to foster energy conservation in buildings and community systems, industry, and transportation will continue in 1987.

The 1987 budget continues to provide for a broad program of research in nuclear *fission* and *fusion* energy technologies. Total obligations for these R&D programs will be about \$650 million in 1987, a decrease of \$88 million from 1986. Conduct of R&D will total approximately \$600 million, and funding for related facilities will be \$49 million.

In the *fission* program, obligations of \$302 million are estimated for the conduct of R&D in 1987, a decrease of \$45 million from 1986. Total obligations for R&D facilities in 1987 will be \$23 million. Major portions of the nuclear fission R&D program are being restructured to phase down the advanced civilian reactor program, including breeder reactors, and to shift efforts toward R&D on reactor concepts that can meet space and military nuclear power requirements. The restructured program, while serving national security interests, will also maintain a technical and industrial base for any future deployment of advanced nuclear technologies in the commercial sector. The fission R&D program will also seek to resolve technical issues associated with the technology of nuclear waste storage and consequent environmental impacts.

In the *magnetic fusion* program, funding of \$304 million is proposed for the conduct of R&D, a decrease of \$18 million from 1986. This reduction slows the pace of fusion reactor development consistent with national energy needs and continues the shift in program emphasis toward resolving scientific questions key to the ultimate achievement of fusion energy. In 1987, the fusion program will focus on the development of the toroidal magnetic confinement system by supporting the continued operation of Princeton's large tokamak test reactor (TFTR), and the first year of operations of GA Technologies' Doublet-III-D machine and the Oak Ridge National Laboratory's ATF torsatron. Fabrication of three smaller toroidal devices initiated in 1986 will continue in 1987: a reversed field pinch machine (RFP) at Los Alamos, a compact toroid called a field reversed configuration (FRC) experiment, and a shaped plasma tokamak (PBX-U) at Princeton. Total obligations for R&D facilities in 1987 will be \$26 million. Ignition studies aimed at a final design of a burning plasma tokamak and studies to support the President's Geneva initiative on expanded cooperation with the Soviets in fusion research will also be funded in 1987.

Funds for the *uranium enrichment* R&D program for 1987 total \$50 million. This program develops advanced technologies for separation and enrichment of uranium. In 1986, DOE selected the Atomic Vapor Laser Isotope Separation (AVLIS) process for future

development. In 1987 DOE will take steps to transfer to the private sector in 1988 the responsibility for further development of AVLIS.

Finally, the *energy program* supports R&D to determine the biological and environmental effects of energy production and use. The *biological and environmental research* R&D program emphasizes the health effects of radiation, the use of radiation in medical diagnosis and therapy, and generic biological research related to radiation and other cellular traumas. This program also supports environmental research in areas related to energy technologies, such as atmospheric processes involved in acid rain formation and deposition and carbon dioxide-induced climatic effects. The level of funding for such activities will be \$197 million in 1987, an increase of \$16 million above 1986. Funding in 1987 for radon-related, acid-rain-related, and carbon-dioxide-related research is over \$23 million.

Table K-8 provides the details of funding for the Department of Energy.

Table K-8. DEPARTMENT OF ENERGY

(In millions of dollars)

Type of activity	1985 actual	1986 estimate	1987 estimate
OBLIGATIONS			
Conduct of R&D:			
National defense program.....	2,251	2,246	2,609
General science program.....	515	515	602
Energy program.....	2,135	2,025	1,674
Total conduct of R&D.....	4,901	4,785	4,886
Total conduct of basic research, included above.....	(926)	(922)	(1,045)
R&D facilities.....	909	813	759
Total obligations.....	5,809	5,598	5,645
OUTLAYS			
Conduct of R&D.....	4,900	4,778	4,819
R&D facilities.....	958	902	826
Total outlays.....	5,858	5,680	5,645

DEPARTMENT OF HEALTH AND HUMAN SERVICES

The Department of Health and Human Services will obligate a total of \$5.5 billion in 1987 for the conduct of R&D, a decrease of \$63 million below the 1986 level. Within this total, funding for basic research is estimated to be \$3.4 billion. Obligations for R&D facilities will total \$10 million in 1987.

Health.—Almost 85 percent of the Department's funds for the conduct of R&D will be obligated by the National Institutes of Health for biomedical research to advance the nation's capabilities for the prevention, diagnosis, and treatment of disease. Several

other agencies within the Department—the Alcohol, Drug Abuse, and Mental Health Administration, the Food and Drug Administration, the Centers for Disease Control, the Health Resources and Services Administration, the Health Care Financing Administration, and the Office of the Assistant Secretary for Health—also support health-related research.

The *National Institutes of Health (NIH)* consist of 12 separate Institutes which will obligate \$4.7 billion in 1987 for the conduct of R&D, a 5 percent decrease below the 1986 level. In addition to these direct obligations, NIH will obligate an additional \$144 million for AIDS research. To ensure a coordinated Federal response to AIDS, these amounts are funneled through the Office of the Assistant Secretary for Health. NIH will fund 18,000 research project grants, 523 centers, and 9,100 research trainees in 1987. Continued emphasis will be given to support of basic research in 1987. Over one-half, or \$2.9 billion, of NIH's proposed R&D budget will support basic research, along with \$144 million in reimbursable AIDS-related obligations. Together, this represents a slight increase over the comparable 1986 NIH level of \$3.1 billion.

Among the continuing R&D activities to be supported by NIH are:

- basic research on cancer chemoprevention, including studies of nutritional factors; rehabilitation of patients with chronic obstructive pulmonary disease; prevention of glaucoma; diagnostic imaging; biological response to chemicals; immunology and neurobiology, including development and application of molecular biology techniques;
- clinical research with emphasis on medical intervention in the disease process, including prototype development and refinement of products, techniques, processes, methods, and practices;
- continuation of cooperative clinical trials on the Acquired Immune Deficiency Syndrome (AIDS); isolated systolic hypertension in the elderly; herpes simplex virus vaccine; antiviral drugs against neonatal herpes, herpes encephalitis, and genital herpes; the efficacy of interferon for controlling the frequency and severity of multiple sclerosis; gonococcal vaccines and the prevention of premature labor, and the role of folic acid in neural tube defects; and
- increased basic clinical research into the cause, cure, and prevention of arthritis under the auspices of the newly-created National Institute of Arthritis and Musculoskeletal and Skin Diseases.

The *Alcohol, Drug Abuse and Mental Health Administration (ADAMHA)* conducts studies on the causes, prevention and treatment of alcohol and drug abuse and on mental disease and neuro-

logical disorders, with emphasis on improving knowledge of effective prevention of these public health problems.

The 1987 budget proposes to stabilize ADAMHA's extramural research programs in biomedical, behavioral and clinical areas by supporting 1,400 research project grants per year. Obligations will decrease in 1987 to \$383 million, \$13 million below 1986.

Specific research areas to be addressed include:

- the neurosciences, behavioral sciences, psychopharmacology, and clinical investigations and evaluations of services to the mentally ill, with special emphasis on preventing and diagnosing mental and emotional problems in children;
- drug abuse among the nation's youth, including studies on the adverse health hazards of marijuana and cocaine; and
- causes and consequences of alcohol abuse, particularly among teenagers.

The *Food and Drug Administration* supports research relevant to its mission of regulating food, drugs, biologics, medical devices and radiological products. In 1987, obligations for these activities are estimated at \$82 million.

The *Centers for Disease Control* support studies on the epidemiology and control of communicable diseases and on health promotion and disease prevention. In 1987, obligations for these activities are estimated at \$49 million.

Other Health Related Agencies within the Department support research in areas such as the effect of socioeconomic factors on social security programs and the economy; survey methods and techniques for analysis of health statistics; and the organization, delivery, and financing of health services. This support is provided through programs of the Health Resources and Services Administration, the Office of the Assistant Secretary for Health and the Health Care Financing Administration.

Human services.—The Department's obligations for R&D in human services programs in 1987 will be \$35 million. The proposed budget will support a variety of development and social services research aimed at improving the Head Start program; the quality of life for the elderly; knowledge of child abuse and neglect; day care systems; family and community support systems; and fostering independence for the disabled.

Table K-9 provides details of the R&D funding of the Department of Health and Human Services.

Table K-9. DEPARTMENT OF HEALTH AND HUMAN SERVICES—RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity and organizational units	1985 actual	1986 estimate	1987 estimate
OBLIGATIONS			
Conduct of R&D:			
Health:			
National Institutes of Health.....	4,824	4,905	4,672
Alcohol, Drug Abuse, and Mental Health Administration.....	378	396	383
Food and Drug Administration.....	82	79	82
Centers for Disease Control.....	46	48	49
Health Care Financing Administration.....	35	22	19
Office of the Assistant Secretary for Health.....	18	18	224
Health Resources and Services Administration.....	19	10	9
Subtotal, Health.....	5,401	5,478	5,437
Human Services:			
Social Security Administration.....	10	13	13
Office of Human Development Services.....	23	27	17
Departmental Management.....	10	6	5
Subtotal, Human Services.....	43	46	35
Total conduct of R&D.....	5,444	5,524	5,471
Total conduct of basic research, included above.....	(3,229)	(3,290)	(3,353)
R&D facilities.....	43	54	10
Total obligations.....	5,487	5,578	5,481
OUTLAYS			
Conduct of R&D.....	4,997	5,561	5,532
R&D facilities.....	43	46	27
Total outlays.....	5,040	5,606	5,558

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) supports primarily basic research in all disciplines through grants to scientists and engineers in academic institutions. NSF support is particularly important because it complements the basic research programs of other agencies and assists in balancing Federal support for promising research across all fields of science and engineering.

The 1987 NSF budget provides \$1.5 billion in obligations for the conduct of R&D, an increase of \$174 million or 13 percent above 1986. Within this total, support for basic research will increase by more than 13 percent.

Although the principal growth in the 1987 budget will be in the support of basic research at academic institutions through project grants, efforts will also be made to provide opportunities to train future scientists and engineers, and to provide the research facilities and equipment necessary to improve the productivity of academic researchers. High priority will be given to strengthening

support for the physical sciences in fundamental research areas such as mathematics, computational sciences, and global geosciences, for engineering, and for molecular and cell biology. Additional studies of the continental lithosphere will be funded, including investigations of potential future lithospheric and seismological projects.

In addition, the 1987 budget will provide increased funds:

- for the Engineering Research Centers (ERC) program, initiated in 1985. The first six awards were made in the spring of 1985 in a wide variety of research areas including robotics, biotechnology and intelligent manufacturing systems. Research in these areas has the potential to make important contributions to the long-term competitiveness of the U.S. economy, particularly in high-technology-dependent industries. NSF expects to support a total of approximately 15 ERCs in 1987. In addition, an important component of the ERC program is the provision of enhanced opportunities for the training of future engineers.
- to increase the access of academic scientists to supercomputers. In 1987, the Phase 2 supercomputer centers at Princeton, the University of Illinois and the University of California at San Diego will be in full operation. It is anticipated that one or two Phase 1 centers with unique capabilities will remain in operation in 1987. There will also be continuing emphasis on development of a national network to link academic researchers to the supercomputer centers.
- to continue ongoing projects, such as the acquisition of the Advanced Vector Computer at the National Center for Atmospheric Research, the construction of the Very Long Baseline Array radiotelescope, and major improvements at the Cornell Electron Storage Ring accelerator.

DEPARTMENT OF AGRICULTURE

The Department of Agriculture supports research and development in several disciplines related to agriculture and forestry to ensure the continued high productivity of U.S. agricultural and forest lands.

Obligations of the Department for the conduct of research and development are expected to total \$907 million in 1987, compared to the \$922 million in 1986. Of the total, \$434 million will support basic agricultural research, maintaining the 1986 estimated level. The Department's 1987 Budget for research and development is highlighted below by major bureau.

The *Agricultural Research Service* expects to obligate \$497 million in 1987 to conduct basic and applied research in plant and animal productivity; commodity conversion and delivery; soil and

water conservation; and integration of systems. This is an increase of \$34 million in obligations over 1986. In 1987, increased emphasis will be placed on basic research in plant germplasm and biotechnology to improve the profitability and competitiveness of U.S. agriculture. An initiative to develop new uses for surplus agricultural commodities is also included.

The *Cooperative State Research Service (CSRS)* estimates that \$234 million will be obligated in 1987. CSRS supports research on agriculture and forestry through grants to land-grant colleges. Also, within CSRS, the Competitive Research Grants program funds basic research in biotechnology, plant and animal science, pest science, and human nutrition.

The *Forest Service* estimates that \$112 will be obligated for research and development in 1987. This represents a decrease from the \$120 million obligated in 1986. The long-range goal of forestry research is to provide the information needed to manage and protect forest and range land resources, and to gain maximum economic and social benefits from their use.

Other Departmental programs will obligate approximately \$64 million for R&D in 1987, covering a broad spectrum of research activities, such as research in agricultural economics, international agricultural cooperation, and statistical reporting.

DEPARTMENT OF COMMERCE

The Department of Commerce undertakes research primarily in ocean science and engineering, meteorology and weather forecasting, and in the maintenance of measurement standards to support science and industry.

Obligations for the conduct of R&D by the Department in 1987 are estimated at \$297 million, a decrease of \$83 million from 1986. This reflects reduced levels of support by the National Oceanic and Atmospheric Administration and the National Bureau of Standards for applied research, that is more appropriately the responsibility of state and local governments or the private sector.

National Oceanic and Atmospheric Administration (NOAA).—NOAA obligations for the conduct of research and development in 1987 will decrease from \$256 million to \$192 million as a result of greater reliance on support from the private sector and state and local governments, and elimination of lower priority research in such programs as Seafloor Spreading Center Research, National Undersea Research Program, National Sea Grant College Program, and some programs of the National Marine Fisheries Service. NOAA will increase R&D programs on Radiatively Important Trace Species (RITS) and hurricane predictions, and will develop a thermodynamic Profiler system. Acid rain research and R&D to support the Pacific Salmon Treaty will be maintained.

National Bureau of Standards (NBS).—NBS conducts research aimed at maintaining and improving a system of measurement required to support the nation's industrial and scientific endeavors. In 1987, NBS is expected to obligate \$91 million for the conduct of R&D. This represents a decrease of \$8 million from 1986. This decrease reflects program changes affecting all areas of technical research activities at NBS. However, funding will increase to support development of measurements and standards to assure reliable performance of advanced ceramics, and development of measurement technology and services for components of optic fiber systems to support industrial development and to ensure international competitiveness. In addition, construction of a new Cold Neutron Research facility used for materials science will be initiated. Funding for several programs, including fire and building research, the Computer Sciences and Technology Program, the Technical Competence Program, and the Research Associates Program will be terminated or reduced because such research can and should appropriately be supported by other sectors of the economy.

Other Commerce R&D Activities.—Funding for smaller R&D programs in the Department, which include those in General Administration, the Bureau of the Census, the Economic Development Administration, and the National Telecommunications and Information Administration, are proposed at \$14 million in 1987, a decrease of \$10 million from the 1986 level.

DEPARTMENT OF THE INTERIOR

The R&D activities of the Department of the Interior principally derive from its broad-ranging responsibilities for management of the nation's natural resources, including developing energy and mineral resources, and restoring and preserving wildlife habitats. R&D programs also serve the needs of other Federal agencies and the private sector.

Obligations for the conduct of R&D for the Department of the Interior for 1987 are estimated at \$345 million. This represents a decrease of \$36 million from the 1986 level. It reflects reductions in activities of a lower priority and elimination of those activities more appropriately conducted by state and other units of government or the private sector, e.g., the Mineral Institutes.

About 91 percent of the Department's 1987 funds for the conduct of R&D will be obligated by the Geological Survey (\$204 million), Fish and Wildlife Service (\$49 million), and the Bureau of Mines (\$61 million). Highlights of the 1987 research objectives of these and other departmental programs are described below.

The *Geological Survey* undertakes research on the extent, distribution, and character of the nation's natural resources and on the geologic processes, structures, and hazards that affect the develop-

ment and use of the land and physical environment. For 1987, obligations will decrease by \$14 million, to a total of \$204 million.

Research in 1987 will be directed toward:

- accurate appraisals of mineral resources and new improved methods of mineral exploration;
- development of basic data on geologic principles and processes;
- improvement of the scientific basis for appraisal and evaluation of water resources; and
- development and application of new technologies, including remote sensing, to prepare cartographic information.

The *Fish and Wildlife Service* supports research in the Service's laboratories and field stations and cooperative efforts with state fish and game departments. It also provides Federal aid to states for research on restoration of fish and wildlife resources. This research provides basic biological information about species numbers, population dynamics, ecological relationships, and habitat requirements. Obligations will total \$49 million in 1987.

The Fish and Wildlife Service will support research activities concerned with:

- the habitats of waterfowl, migratory and non-migratory birds, and mammals;
- the status and distribution of endangered and threatened species;
- impact of broad-scale environmental changes on fish and wildlife populations and habitat; and
- diseases of freshwater and anadromous fish.

The *Bureau of Mines* conducts basic and applied research across the minerals cycle to improve understanding of the principles of mining and minerals processing and to reduce associated health hazards. Obligations for the conduct of R&D are expected to decrease by \$22 million to \$61 million in 1987. This decrease in obligations is the result of proposed reductions in applied research, particularly in projects which are more appropriate for support by non-Federal sources. The 1987 budget reflects continued emphasis on strategic and critical minerals R&D activities and stresses:

- long-range, high-risk research in extractive metallurgy technology;
- development of domestic source substitutes for imported strategic and critical minerals;
- health-related research on the proper quality and quantity of air flow in underground mines; and,
- long-term, generic research on mine disaster prevention, ground control, industrial hazards, explosives, and systems engineering.

Other Departmental Programs expect to obligate about \$31 million in 1987, a decrease of about \$3 million from 1986.

DEPARTMENT OF TRANSPORTATION

The R&D program of the Department of Transportation is oriented toward providing the information and new technology needed for its own operational (e.g., air traffic control) programs and for regulatory (e.g., automotive and aircraft safety standards) programs. Obligations for the conduct of research and development by the Department are estimated at \$277 million for 1987, a decrease of \$86 million from 1986.

The *Federal Aviation Administration* (FAA) is expected to obligate \$144 million in 1987. The proposed 1987 R&D obligations for FAA represents a decrease from 1986 of \$72 million. This decrease is associated with reduced requirements for the National Airspace System Plan.

Development and testing of the Advanced Automation System to automate air traffic control in the 1990's will continue. FAA will support other research activities concerned with Automated En Route Air Traffic Control (AERA); communications system development; Central Weather Processor (CWP); terminal doppler weather radar; and development of devices to detect weapons, explosives and flammable liquids.

The *National Highway Traffic Safety Administration* will obligate \$27 million for motor vehicle and highway safety research, and demonstrations emphasizing safety belt usage and alcohol countermeasures. In 1987, a small increase is planned for safety belt activity.

The *Urban Mass Transportation Administration* (UMTA) is expected to obligate \$8 million to conduct research, training, and human resources programs in all phases of urban mass transportation to improve mass transportation services (especially in urban areas) and reduce costs. In addition, UMTA will support interdisciplinary academic research including training of personnel to conduct further research or to obtain employment in urban mass transportation planning, construction, operation or management.

The *Federal Highway Administration* will obligate \$54 million to continue support for research programs in highway planning, design, construction, and maintenance to ensure an effective and efficient highway system. Research will also be directed toward identifying and correcting impediments to highway safety and improving truck safety.

The *Federal Railroad Administration* will obligate \$10 million to support R&D efforts to enhance railroad safety.

The *Maritime Administration* will obligate \$6 million in 1987 to support R&D, a decrease of about \$5 million from 1987. The de-

crease reflects movement toward an objective of greater private sector initiative in maritime research and development.

The *U.S. Coast Guard* will obligate \$22 million to support research to maintain and improve search and rescue systems, environmental protection, marine safety, aids to navigation, the enforcement of laws and treaties, and activities affecting all Coast Guard missions. The proposed 1987 figure represents a decrease of \$2 million below the 1986 level.

The *Research and Special Programs Administration* will obligate \$2 million for R&D in hazardous materials, pipeline safety, radio-navigation, transportation statistics, and emergency transportation.

The *Office of the Secretary* will obligate \$5 million for broad-based policy research on domestic and international transportation issues of importance to the nation.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) conducts research and development in support of its regulatory and enforcement responsibilities to protect human health and the environment. The 1987 budget proposes \$310 million in total obligations represents a reduction of 7 percent below 1986. The major research emphases include: (1) a continued commitment to acid rain research to provide a scientifically valid framework for sound policy decisions; (2) increased research on pesticides, including the cross-media problem of pesticides in groundwater; and (3) a strengthened research effort on bioengineered and conventional toxic substances.

The acid rain/energy research program will support the development of more reliable information upon which mitigation decisions may be made. The program directs basic research in areas identified by the Interagency Task Force on Acid Precipitation to provide enhanced data on the physical and chemical mechanisms governing the acid rain phenomenon. This involves research on aquatic effects, forest damage, monitoring trends, and installation of an acid rain monitoring network.

The pesticides program will support the development of methods to detect the presence of an exposure to pesticides in groundwater, and to assess management strategies to prevent such contamination. Pesticides research will also support studies on the effects of bioengineered pesticides, and validation of models for predicting exposure to, transport and fate of, pesticides.

The toxic substances research program will continue to address any potential hazards associated with products of biotechnology, as well as to support ongoing work on the human health risks and environmental effects associated with toxic pollutants. Toxic substances research will also serve to improve pollutant monitoring methods.

The hazardous waste research program will address several areas of study needed to implement regulations required by the 1984 RCRA Amendments. Risk assessment studies will be used in agency decisions to list and ban hazardous wastes. Studies will be conducted on methods to detect leaks from underground storage tanks.

Under the President's reauthorization proposal, the Superfund research program will expand to provide technical support to EPA's Regional Offices to conduct geophysical surveys at an increased number of Superfund sites. Quality assurance support to contract laboratories will be provided.

The drinking water research program will examine the health effects of complex chemical mixtures. Also, the transport and fate of contaminants in the subsurface environment will continue to be identified through the groundwater research program.

The air research program will continue to provide monitoring methods, air quality models, health and welfare assessments, and emission reduction technology evaluations to assess National Ambient Air Quality Standards, promulgate New Source Performance Standards and National Emissions Standards Hazard Assessment Protocols and develop State Implementation Plans.

VETERANS' ADMINISTRATION

The Veterans' Administration (VA) conducts and administers medical, rehabilitation, and health services research designed to improve the quality and increase the effectiveness of health care for the veteran. In 1987, the VA will obligate \$194 million for the conduct of R&D. This is an increase of \$8 million above 1986.

The VA biomedical research program covers a wide range of medical problems, with special emphasis on Agent Orange, aging, alcoholism, post-traumatic stress, the health problems of female veterans and former prisoners of war, schizophrenia, spinal cord injury and tissue regeneration.

Rehabilitation research focuses on the problems of the disabled veteran and develops sensory aids for impaired vision and hearing. This work brings the latest electronic and computer technology to bear on problems of prosthetics, orthotics, wheelchair design, and spinal cord injury (including functional electrical stimulation of muscles in paralyzed limbs).

Health services research is designed to help health care professionals and managers to improve the effectiveness, economy, and accessibility of health care services provided to the veteran. Research in this area deals with such areas as aging and preventive medicine.

AGENCY FOR INTERNATIONAL DEVELOPMENT

Research and development activities of the Agency for International Development (AID) consist mainly of applied research to solve specific problems associated with basic human needs and social and economic research aimed at improving U.S. and host-country understanding of the barriers to development. Programs under AID reflect the administration's recognition of the importance of R&D in addressing the problems faced by the Third World. Over the years, AID has provided substantial support to research efforts undertaken by U.S. universities and international research centers such as the International Rice Research Institute in the Philippines.

Obligations by AID for the conduct of R&D are estimated at \$203 million for 1987, a decrease of \$3 million from 1986.

AID will continue to support research aimed at improving agricultural production capability, with an emphasis on efforts to overcome the mounting food crisis in Third World nations. R&D funds will also be devoted to two other critical problems: population growth, emphasizing methods of controlling increasing population growth rates in the developing countries, and energy supply, emphasizing renewable and nonconventional energy sources critical for development to proceed.

Significant research efforts are also being pursued in two other promising areas: oral rehydration therapy and a malaria vaccine. The former holds the promise of significantly reducing the incidence of child mortality associated with diarrheal diseases, currently estimated to claim the lives of over 1 million children annually. Similarly, AID-supported research on a malaria vaccine may lead to a breakthrough in controlling a disease which currently infects some 200 million people worldwide and is the leading cause of death in Third World nations.

OTHER AGENCY PROGRAMS

An additional 10 departments and agencies (listed in table K-2, footnote 1) will obligate an estimated \$531 million in 1987, for the conduct of R&D, essentially the same as in 1986. Obligations by these agencies amount to less than 1 percent of all federally-funded programs in R&D. The programs of these agencies, like those of other agencies discussed above, are closely related to serving the agencies' missions.

Among the agencies in this category that expect to increase their obligations for R&D in 1987 are the Smithsonian Institution, the Tennessee Valley Authority, and the Departments of Labor, Housing and Urban Development, and Treasury.

Table K-10 provides information on the long-term trends in Federal funding for the conduct of R&D.

Table K-10. TRENDS IN CONDUCT OF R&D

(Obligations in billions of dollars)

Year	Defense ¹	All other	Total	Basic research ²
1960.....	6.1	1.5	7.6	0.6
1961.....	7.0	2.1	9.1	0.8
1962.....	7.2	3.1	10.3	1.0
1963.....	7.8	4.7	12.5	1.2
1964.....	7.8	6.4	14.2	1.3
1965.....	7.3	7.3	14.6	1.4
1966.....	7.5	7.8	15.3	1.6
1967.....	8.6	7.9	16.5	1.8
1968.....	8.3	7.6	15.9	1.8
1969.....	8.4	7.2	15.6	1.9
1970.....	8.0	7.3	15.3	1.9
1971.....	8.1	7.4	15.5	2.0
1972.....	8.9	7.6	16.5	2.2
1973.....	9.0	7.8	16.8	2.2
1974.....	9.0	8.4	17.4	2.4
1975.....	9.7	9.3	19.0	2.6
1976.....	10.4	10.4	20.8	2.8
1977.....	11.9	11.6	23.5	3.3
1978.....	12.6	13.2	25.8	3.7
1979.....	13.6	14.5	28.1	4.2
1980.....	15.1	14.7	29.8	4.7
1981.....	17.8	15.3	33.1	5.0
1982.....	22.1	14.3	36.4	5.5
1983.....	24.5	13.9	38.4	6.4
1984.....	28.3	14.9	43.2	7.0
1985.....	33.4	16.1	49.5	7.8
1986 (estimate).....	35.7	16.3	52.0	8.0
1987 (estimate).....	44.4	16.4	60.8	8.6

¹ Includes military-related programs of the Departments of Defense and Energy.² Included in totals for conduct of R&D.

SPECIAL ANALYSIS J

RESEARCH AND DEVELOPMENT

This analysis covers the funding of research and development across all agencies with R&D programs of \$10 million or more. It consists of two sections. The first highlights the R&D policies and trends in the 1988 budget. The second describes in more detail the R&D programs of 12 agencies whose R&D obligations individually exceed \$150 million. These agencies fund over 99 percent of total Federal R&D.

PART I. HIGHLIGHTS

In 1988, total Federal obligations for research and development, including R&D facilities, are estimated at \$66.7 billion, an increase of over \$7 billion or 12 percent above the 1987 estimated level of \$59.5 billion as shown in table J-1. Support for the conduct of basic research, included within this total, is estimated to increase by about 4 percent, from \$8.8 billion in 1987 to \$9.1 billion in 1988.

The Federal Government supports research and development:

- to meet the direct needs of the Federal Government where the supporting agencies are also the principal users of the results of the R&D. Examples include R&D for national security and research to support regulatory activities; and
- to assist in meeting broad national needs, particularly where the private sector lacks sufficient incentives for adequate investment to assure long-term economic growth and continued improvement in the quality of life for all citizens. Examples of such R&D include Federal investments in basic research across all fields of science and engineering, and agricultural and health-related R&D.

The ability of the Nation to meet global competition, to provide for the national security, and to improve the quality of life for all citizens depends in part on national investments in science and technology. For 1988, the budget provides increased support for R&D to meet key national needs. The budget also provides increased support for basic research, particularly at universities, to help generate the new knowledge necessary for continued technological innovation and to help assure the future availability of high-quality scientists and engineers. Interdisciplinary basic research will receive special emphasis, since research at the junction of disciplines can lead to the creation of important new fields of

science. The Federal government will also increase efforts to help encourage the transfer to the private sector of technology and new knowledge created in Federal laboratories.

Even in a constrained fiscal climate, the 1988 budget reflects a continued high priority for R&D that is appropriate for Federal support. It provides significant increases for:

- the R&D programs of the Department of Defense;
- the R&D programs of the National Aeronautics and Space Administration; and
- selected basic research activities across the government, particularly basic research support by the National Science Foundation and the Department of Energy.

At the same time, the 1988 budget continues to propose reductions in programs that are not an appropriate Federal responsibility and which should be left to the states or the private sector for needed investments. These include large reductions across the energy technology programs of the Department of Energy, as well as elimination of selected programs of the Department of Commerce (e.g., the Sea Grant program), and certain research activities of the Department of Interior (e.g., the Mineral Institutes program).

Table J-1. TOTAL FEDERAL FUNDING FOR CONDUCT OF R&D AND RELATED FACILITIES

(In billions of dollars)

	Obligations			Outlays		
	1986 actual	1987 estimate	1988 estimate	1986 actual	1987 estimate	1988 estimate
Conduct of R&D	52.6	57.6	64.8	51.6	54.6	59.1
R&D facilities	1.6	1.9	2.0	1.6	1.8	1.9
Total	54.2	59.5	66.7	53.1	56.3	61.0

CONDUCT OF RESEARCH AND DEVELOPMENT

The budget for 1988 includes nearly \$65 billion in obligations for the conduct of R&D, an increase of \$7 billion or 12 percent over 1987. Highlights of the proposed programs of the seven major R&D agencies, which account for 97 percent of the obligations for the conduct of R&D by the Federal Government, are presented below.

- **Department of Defense (DOD).**—Obligations for the conduct of R&D by DOD are estimated at \$44.1 billion for 1988, an increase of \$6.5 billion or about 17 percent above 1987. The increased funds proposed for R&D allow growth for several important programs, including the Strategic Defense Initiative, the Advanced Tactical Fighter and the Small Intercontinental Ballistic Missile. There is also an increase for the joint

NASA-DOD program to explore technologies for a future transatmospheric vehicle (National Aerospace Plane).

- **Department of Energy (DOE).**—Obligations for the conduct of R&D by the Department of Energy are estimated to be \$5.0 billion, an increase of \$215 million over 1987. Increases are proposed to strengthen the Nuclear Weapons R&D program, to enhance support for long-term energy research, and to maintain a strong national basic research effort in High Energy and Nuclear Physics. Support for the energy technology programs will remain at nearly the same levels as in 1987. Obligations for Energy Programs will increase by \$14 million over 1987 to \$1,862 million in 1988. Funding for the National Defense Program will increase by over 6 percent to \$2,531 million. High Energy and Nuclear Physics R&D will increase from \$575 million in 1987 to \$623 million in 1988. Included in this total are funds for the first full year of operation of 3 newly completed accelerator facilities: the Stanford Linear Collider in California, the Tevatron Collider at Fermi National Laboratory in Illinois, and Tandem/Alternating Gradient Synchrotron at Brookhaven National Laboratory in New York.
- **Department of Health and Human Services (HHS).**—HHS R&D activities in 1988 will continue to be funded at stable and sustainable levels. In 1988, the National Institutes of Health (NIH) will support about 19,100 research project grants, about 560 research centers, and about 10,900 research trainees. In addition, the budget proposes funding for the full, multi-year costs of grant commitments incurred in 1988. This would eliminate annual uncertainties over the level and timing of allotments for grantees and ensure proper review of the full cost of funding additional grants. In 1988, total HHS obligations will approach \$6.3 billion.
- **National Aeronautics and Space Administration (NASA).**—NASA obligations for the conduct of R&D are estimated at about \$4.5 billion in 1988, an increase of \$313 million over 1987. This increase is necessary primarily to continue development of the Space Station and to provide for two new initiatives, the Global Geospace Science program (GGS) and the Civil Space Technology Initiative (CSTI). GGS will expand international cooperative efforts to investigate the interaction of the Sun with the Earth's environment, and CSTI will explore a variety of generic space technologies important to continued U.S. leadership in space. For other science and applications programs, the budget continues support for major flight projects such as the Space Telescope, the Galileo mis-

sion to Jupiter, the Upper Atmosphere Research Satellite (UARS), and the Ocean Topography Mission (TOPEX).

- **National Science Foundation (NSF).**—Obligations for research supported by NSF are expected to increase by about \$238 million, or about 17 percent—to \$1.7 billion in 1988. The budget principally provides enhanced support for basic research across a wide spectrum of high-priority scientific and engineering disciplines, including materials sciences, computational science and engineering, and biotechnology. Increases will also be provided for instrumentation and graduate student support. The budget also provides for significant new efforts in improving research and education at the undergraduate level, and for the initiation of a new activity, Basic Science and Technology Centers. These new centers, modeled after the Engineering Research Centers, are intended to foster and strengthen multidisciplinary research in the basic physical and life sciences.
- **Department of Agriculture (USDA).**—Obligations for the conduct of R&D are estimated at \$961 million for 1988, a decrease of about 2 percent from the 1987 level of \$978 million. Within the USDA total, the Cooperative State Research Service will provide \$238 million for research and development, primarily conducted by colleges and universities. The Agricultural Research Service expects to obligate \$527 million, an increase of \$37 million over 1987, with emphasis on basic research in plant germplasm, biotechnology, new agricultural products, and the improvement of commodity exports. The Forest Service will continue its research on land management planning and forest inventory.
- **Department of Commerce (DOC).**—Obligations for R&D undertaken by DOC decrease by \$63 million from 1987 to \$333 million in 1988. The proposed reductions reflect the Administration's continued efforts to reduce funding for programs that are more appropriately the responsibility of the private sector and state or local governments. Programs proposed for elimination include the Sea Grant and National Undersea Research Programs of the National Oceanic and Atmospheric Administration (NOAA), and reductions are proposed in the fire and building research programs at the National Bureau of Standards (NBS). Increases are proposed for NBS in areas of growing importance, such as optical fiber systems. The budget also provides for an increase in construction funding for the Cold Neutron Research Facility at NBS.

Table J-2 summarizes Federal support for the conduct of R&D by agency.

Table J-2. CONDUCT OF RESEARCH AND DEVELOPMENT BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1986 actual	1987 estimate	1988 estimate	1986 actual	1987 estimate	1988 estimate
Defense-Military functions.....	34,205	37,533	44,080	33,292	35,153	39,112
Health and Human Services.....	5,661	6,353	6,294	5,504	6,012	6,187
(National Institutes of Health).....	(5,004)	(5,519)	(5,573)	(4,845)	(5,211)	(5,458)
Energy.....	4,708	4,801	5,016	4,705	4,819	4,863
National Aeronautics and Space Administration.....	3,420	4,185	4,498	3,432	3,711	4,159
National Science Foundation.....	1,336	1,441	1,680	1,392	1,390	1,604
Agriculture.....	925	978	961	914	952	999
Transportation.....	387	308	290	430	390	306
Interior.....	378	366	364	386	373	370
Environmental Protection Agency.....	317	329	346	307	333	352
Commerce.....	394	397	333	373	375	314
Agency for International Development.....	211	217	233	195	300	171
Veterans Administration.....	188	211	214	183	214	209
All other ¹	483	514	463	464	525	463
Total.....	52,612	57,631	64,771	51,576	54,548	59,108

¹ Includes the Departments of Education, Justice, Labor, Housing and Urban Development and Treasury, the Tennessee Valley Authority, the Smithsonian Institution, the Corps of Engineers, and the Nuclear Regulatory Agency.

CONDUCT OF BASIC RESEARCH

The 1988 budget continues the already strong emphasis that this Administration has placed on enhancing support for basic research across all scientific and engineering disciplines. Even in a fiscally austere environment, support for basic research, especially at universities, is an important factor in generating new knowledge to ensure continued technological innovation. It is an essential investment in the nation's future. The Federal Government has traditionally assumed a key role in support of basic research because the private sector has insufficient incentives to invest in such research.

Funding for basic research is included within the overall Federal support for the conduct of R&D. In 1988, obligations for the conduct of basic research are estimated at \$9.1 billion, an increase of \$312 million, or almost 4 percent above the level for 1987.

Support for basic research at universities serves the dual role of providing new knowledge and helping to ensure the future availability of high-caliber scientists and engineers. Both of these are key elements in the long-term ability of the nation to compete in global markets. University-based researchers receive about half of the total Federal obligations for basic research. Federal support for R&D at universities and colleges, more than two-thirds of which is basic research, is estimated to increase by over 5 percent in 1988 to a total of almost \$7.7 billion. This would represent an increase of 18 percent over the period 1986 to 1988.

Table J-3 summarizes Federal support for the conduct of basic research by agency.

Table J-3. CONDUCT OF BASIC RESEARCH BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars) ¹

Department or agency	Obligations			Outlays		
	1986 actual	1987 estimate	1988 estimate	1986 actual	1987 estimate	1988 estimate
Agencies supporting primarily physical sciences and engineering: ²						
National Science Foundation.....	1,259	1,359	1,585	1,313	1,310	1,513
Defense—Military functions.....	921	858	907	845	844	811
Energy.....	964	1,084	1,133	947	1,087	1,143
National Aeronautics and Space Administration.....	917	1,069	1,016	932	983	1,002
Interior.....	129	123	115	135	129	118
Commerce.....	26	24	24	27	23	24
Other Agencies ³	10	10	9	11	11	10
Subtotal.....	4,227	4,527	4,788	4,210	4,387	4,620
Agencies supporting primarily life and other sciences: ⁴						
Health and Human Services.....	3,335	3,663	3,712	3,234	3,475	3,579
(National Institutes of Health).....	(3,118)	(3,360)	(3,442)	(3,013)	(3,185)	(3,308)
Agriculture.....	431	454	454	419	440	474
Smithsonian Institution.....	63	73	78	59	67	72
Environmental Protection Agency.....	39	38	39	36	39	40
Veterans Administration.....	15	16	16	15	15	16
Education.....	11	12	11	8	15	11
Other Agencies ⁵	17	16	13	14	15	15
Subtotal.....	3,909	4,271	4,322	3,786	4,067	4,207
Total.....	8,137	8,798	9,110	7,996	8,454	8,827

¹ Amounts reported in this table are included in totals for conduct of R&D.² Includes mathematics and computer sciences.³ Includes the Corps of Engineers, the Tennessee Valley Authority, and the Department of Transportation.⁴ Includes psychology and social sciences.⁵ Includes the Departments of Labor, Justice, and Treasury, and the Agency for International Development.

R&D FACILITIES

In 1988, within the total for support for R&D facilities, funding is provided for major scientific instrumentation, including the specialized research facilities at national laboratories and university centers, e.g., particle accelerators, telescopes, and advanced computers. Such specialized facilities are critical to advancing the frontiers of science in a number of scientific disciplines. Funds for R&D facilities are also used for construction or renovation of general purpose laboratories and research support facilities.

In 1988, obligations for R&D facilities are expected to total nearly \$2.0 billion, an increase of \$57 million from 1987. The budget provides for construction of several major new projects in DOE, including the 1-2 GeV synchrotron source at Lawrence Berkeley Laboratory, the Accumulator Booster Ring at the Brook-

haven Alternating Gradient Synchrotron, and a new 3 GeV injector for the SPEAR storage ring at the Stanford Synchrotron Radiation Laboratory.

Table J-4 summarizes Federal support for R&D facilities and capital equipment.

Table J-4. RESEARCH AND DEVELOPMENT FACILITIES BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1986 actual	1987 estimate	1988 estimate	1986 actual	1987 estimate	1988 estimate
Energy.....	750	744	848	784	820	793
Defense—Military functions.....	301	525	502	284	398	409
National Aeronautics and Space Administration..	276	325	420	299	294	384
Agriculture.....	79	93	25	50	68	77
National Science Foundation.....	68	80	94	72	78	90
Health and Human Services.....	41	58	6	33	38	29
(National Institutes of Health).....	(32)	(56)	(5)	(22)	(33)	(26)
All other ¹	48	88	76	46	67	73
Total.....	1,563	1,914	1,972	1,567	1,762	1,854

¹ Includes the Departments of Transportation, Commerce, Education, Interior, Justice, and Treasury, Veterans Administration, Tennessee Valley Authority, Agency for International Development, and the Smithsonian Institution.

ARCTIC RESEARCH

Two complementary policy documents currently govern U.S. Arctic research policy. The Arctic Research and Policy Act of 1984 (Public Law 98-373) requires an “. . . integrated, coherent, and multiagency request . . .” for research in the Arctic as part of the President’s annual budget request to Congress. National Security Decision Directive 90 (NSDD 90, April 14, 1983) identifies four basic elements of U.S. Arctic Policy:

- protection of essential security interests in the Arctic region, including the adjacent seas and airspace;
- support for sound, rational development in the Arctic region, while minimizing adverse effects on the environment;
- promotion of scientific research in fields which contribute knowledge about the Arctic, or which are most advantageously studied in the Arctic; and
- promotion of mutually beneficial international cooperation in the Arctic to achieve the above objectives.

In response to these directives, the Interagency Arctic Research Policy Committee (established by Public Law 98-373) has compiled a detailed listing of agency programs in Arctic research, including budgetary estimates, and has grouped them into three major categories of national concern:

- national security;
- rational development with minimal environmental or adverse social impact; and

- research on Arctic phenomena and on science best studied in the Arctic (the Arctic as a natural laboratory).

The Act also directs that the Interagency Committee, “. . . in consultation with the [Arctic Research] Commission, the Governor of the State of Alaska, the residents of the Arctic, the private sector, and public interest groups, shall prepare a comprehensive 5-year plan for the overall Federal effort in Arctic research . . .” Over the past year, the Interagency Committee, with advice and assistance from the Arctic Research Commission, has developed a draft 5-year plan for Federal Arctic Research, including recommendations for necessary programs.

The Arctic Research and Policy Act requires public participation in the development of recommendations for the 5-year Arctic Research Plan. This requirement has been fulfilled through:

- extensive participation by the scientific community and others in the report by the National Research Council entitled, *National Issues and Research Priorities in the Arctic*;
- presentation of statements from the public before the Interagency Committee; and
- hearings of the Arctic Research Commission.

The Interagency Committee also held a Consultative Workshop in Alaska in November of 1986. Representatives from the groups named in the Act attended the Workshop and agreed to consensus recommendations. It is anticipated that the proposed 5-year Plan will be submitted to the President for transmittal to the Congress prior to the July 31, 1987 deadline established by the Act.

Table J-5 provides a summary of Federal support for Arctic research integrated by major category. These estimates are subsumed within agency totals for the conduct of research and development.

Table J-5. FEDERAL SUPPORT FOR ARCTIC RESEARCH ¹

(Obligations in thousands of dollars)

Category	1986 actual	1987 estimate	1988 estimate
National security	26,125	26,278	26,300
Rational development	32,176	32,774	31,334
Natural laboratory	23,613	27,295	30,590
Total.....	81,914	86,369	88,224

¹ Includes the Departments of Defense, Energy, Health and Human Services, Interior, Commerce, and Transportation, the National Science Foundation, the National Aeronautics and Space Administration, the Environmental Protection Agency, and the Smithsonian Institution.

PART II. AGENCY R&D PROGRAMS

Presented below are summaries of the R&D activities of the 12 agencies whose R&D obligations individually exceed \$150 million.

DEPARTMENT OF DEFENSE

DOD research and development ranges from support of basic research, primarily in the physical sciences, to full scale development of hardware and its testing and evaluation. The primary purpose of DOD R&D is to provide new strategic and tactical weapons and supporting systems to improve the Nation's defense. Obligations for DOD research and development, including R&D facilities, total \$44.6 billion, about 67 percent of total Federal funding for research and development in 1988.

In 1988, DOD obligations for the conduct of R&D will increase by \$6.5 billion, or 17 percent above the 1987 level, to \$44.1 billion. DOD funding of technology base programs (basic and applied research) will increase from about \$3.2 billion in 1987 to about \$3.3 billion in 1988. Funding for R&D facilities will decrease by \$23 million from 1987 to a total of \$502 million in 1988.

By mission category, major R&D efforts for 1988 include:

—*Technology Base and Advanced Technology Development.*—

These programs constitute the research end of the spectrum of programs that comprise Research and Development, Test and Evaluation. The programs are intended to provide choices for future system development and to help avoid technological surprise.

The Strategic Defense Initiative, a program to investigate the feasibility of defense against ballistic missiles, will increase to \$5.3 billion (including \$0.1 billion for facilities) in 1988. Other areas emphasized include the joint NASA-DOD National Aerospace Plane program, materials research, and environmental research important to the military mission. There is also continued emphasis on electronics, including the Very High Speed Integrated Circuits and Millimeter Wave Monolithic Integrated Circuits programs.

—*Strategic Programs.*—Major programs for 1988 include the MILSTAR communications satellite program, the Small Intercontinental Ballistic Missile (Small ICBM), a short range air-launched attack missile, a rail garrison mobile basing mode for the Peacekeeper ICBM and the Advanced Technology Bomber. Development of the Trident II submarine-launched ballistic missile and the Peacekeeper missile near completion.

—*Tactical Programs.*—These programs support the development of systems to increase the capability of U.S. general purpose and theater nuclear forces, and to develop the capability to project forces rapidly anywhere in the world where the vital interests of the United States are threatened. In 1988 these programs include:

- in the Army, development of new munitions for its M1-A1 tank, a new family of trucks and forward area air defenses. Work on the LHX light helicopter will continue.
- in the Navy, development of the Seawolf attack submarine, and the Sealance, a new sub-launched, anti-submarine, stand-off weapon. Other major programs include the V-22 Osprey tilt-rotor aircraft, start of the Advanced Air-to-Air Missile, and continuations of upgrades to the F-14 fighter and A-6 attack airplanes. Several efforts are being continued to improve fleet air defenses.
- in the Air Force, continuing development of the Joint STARS radar, the Advanced Tactical Fighter aircraft, the C-17 transport aircraft, and various electronic warfare programs, including the Airborne Self Protection Jammer. Work on smart munitions and the interdiction version of the F-15 fighter also progresses.

—*Intelligence and Communications, Program Management and Support.*—R&D supported by these programs is directed toward improvements in defense intelligence systems, command control and communications programs, and test and evaluation capabilities. Work will continue in such areas as the use of technology to reduce manufacturing costs and to extend the life and capability of existing defense systems.

Table J-6 provides the details of the Department of Defense military R&D funding.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA invests in R&D programs to provide for a permanent U.S. presence in space with a future space station; to support the Shuttle-based Space Transportation System; to advance knowledge of the Earth, the near-earth environment, the solar system and the universe; and to support long-term research and technology advancement. It also supports long-term research and selected systems technology projects in aeronautics.

R&D accounts for over 50 percent of the total budget for NASA. The balance of the NASA budget includes funding primarily for Shuttle production and operations, tracking and data acquisition activities, and related institutional support.

In 1988, NASA obligations for R&D including facilities for the agency will be approximately \$4.9 billion, a net increase of \$408 million, or 9 percent, over 1987. Within this total, funds are available to complete projects currently under development, to augment major research and technology programs, and to initiate a major new flight project in space science and applications. Within the total funding for R&D, basic research obligations in 1988 are estimated at \$1.0 billion, a decrease of \$53 million from 1987.

Table J-6. DEPARTMENT OF DEFENSE—MILITARY RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity	1986 actual	1987 estimate	1988 estimate
OBLIGATIONS			
Conduct of R&D:			
Research, development, test and evaluation:			
Technology base.....	3,207	3,177	3,345
Advanced technology development.....	4,046	5,091	7,284
Strategic programs.....	7,419	8,095	9,767
Tactical programs.....	10,109	11,383	13,529
Intelligence and communications.....	4,442	4,799	5,191
Program management and support.....	3,936	3,902	3,889
Other appropriations.....	1,178	1,252	1,034
Total conduct of R&D ¹	34,205	37,533	44,080
Total conduct of basic research, included above.....	(921)	(858)	(907)
R&D facilities.....	301	525	502
Total obligations	34,506	38,058	44,582
OUTLAYS			
Conduct of R&D.....	33,292	35,153	39,112
R&D facilities.....	284	398	409
Total outlays	33,576	35,551	39,521

¹ Includes funds for Operational Systems Development of \$8,970 million in 1986, \$9,879 million in 1987 and \$9,881 million in 1988.

Space Station and Space transportation.—Obligations for Space Station R&D are estimated to increase from \$374 million in 1987 to \$663 million in 1988. This increase is consistent with funding needed to pursue design, definition, and development of the space station for planned initial operating capability in the mid-1990's.

The space station is intended to enhance the nation's science and applications programs, to help develop advanced technologies potentially useful to the economy, and to encourage greater commercial use of space.

For Space Transportation the 1988 budget provides for sustained support for the Space Shuttle program to achieve routine and reliable access to space for all planned users, and for continued investments to further improve the safety and reliability of the Shuttle fleet. Other major continuing activities will include planning for the use of Spacelab; further development of the tethered satellite program, a Shuttle-based science program conducted in cooperation with the Italian government; and development of an Orbital Maneuvering Vehicle for future near-Earth orbital transfers.

Space science and applications.—Obligations for space science and applications are estimated in 1988 at \$1.5 billion, a decrease of \$144 million below the 1987 level due in large part to project rephasing to meet the new Shuttle flight schedule. The funding

provided will allow initiation of a major new flight project, continued support of ongoing flight projects, and the analysis of scientific data being sent back to Earth from spacecraft now in space.

The 1988 budget continues support for space science research to enhance understanding of the Sun, the planets, and the universe; space-related research on the Earth's climate, resources, surface and atmosphere; research to advance knowledge in materials science and materials processing through low gravity experiments in space; and continuing long-term basic technology work for satellite communications.

The major new flight project proposed for initiation in 1988 is the Global Geospace Science (GGS) mission. The GGS mission will obtain coordinated measurements of the interaction of the Earth's magnetic field and the solar wind. GGS is the United States' contribution to an international solar terrestrial physics program, which includes spacecraft from the Japanese and European space agencies.

Continuing development efforts for ongoing major flight projects yet to be launched include:

- the Space Telescope, planned for launch in 1989, which is expected to serve as a major astronomy facility for a 10- to 15-year period;
- the Gamma Ray Observatory, planned for launch in 1990, which will enhance basic research in high energy astrophysics, providing new knowledge about objects in deep space;
- Spacelab astronomy experiments, which will be conducted on the Shuttle with the goal of improving our understanding of the Earth's vicinity, the Sun and the universe;
- the Magellan project, planned for launch in 1989, to map the planet Venus;
- the Mars Observer Mission, a major space science project planned for launch in the early 1990's, to continue the scientific exploration of the planet Mars;
- the Galileo orbiter and probe mission to Jupiter, now planned for launch in 1989, to carry out long-term studies of the planet, its satellites, and its magnetosphere;
- the Upper Atmosphere Research Satellite (UARS) spacecraft, to be launched in 1991, to investigate the chemical composition of the Earth's stratosphere and mesosphere;
- the Scatterometer project, a research instrument to measure global wind patterns on the surface of the oceans. This instrument will be flown in 1990; and
- the Ocean Topography Experiment (TOPEX) scheduled for a 1991 launch as part of a collaborative mission with France.

Continued support will be provided in 1988 for several spacecraft already in flight including:

- two Voyager spacecraft, launched in 1977, which have successfully encountered Jupiter and Saturn; Voyager 2 encountered Uranus in January 1986 and is scheduled to fly by Neptune in 1989; and
- a number of smaller, Explorer-class scientific satellites launched in prior years.

The budget also provides for continuing research and technology work in areas such as space-related life science research; near-Earth experiments using balloons and sounding rockets; research in geodynamics, ocean processes, and atmospheric dynamics; Shuttle-based science and applications experiments; and preparations for the future launch of planned missions. Continuing efforts to improve satellite communications technology will be refocused towards generic and longer-term technology-based efforts, in recognition of the responsibility of the private sector to pursue relatively near-term satellite communications technologies.

Commercial Programs.—These programs include the Technology Utilization program which promotes the dissemination of new developments in aerospace technology to industrial sectors other than aerospace, and the Commercial Use of Space program which encourages increased private sector awareness, participation and investment in space technologies.

Transatmospheric research and technology.—In 1988, funding will increase as planned to continue research and advanced technology leading to a transatmospheric flight research vehicle demonstration in the early 1990's. This program is jointly supported with DOD to investigate the technologies necessary for a National Aerospace Plane.

Aeronautical research and technology.—Obligations for aeronautical research and technology are estimated to decrease slightly from \$315 million to \$306 million in the 1988 budget. Ongoing research in fundamental aeronautical disciplines such as materials and structures, propulsion and selected systems technology projects will be continued.

Agency-wide support activities.—Obligations for agency-wide support activities will total \$1.4 billion in 1987, a 13 percent increase above the 1987 level. These programs include primarily R&D-related NASA civil service and administrative costs; tracking and data acquisition system improvements; safety, reliability and quality assurance; and R&D addressing fundamental space technology problems and opportunities common to a wide spectrum of space programs.

The 1988 budget proposes \$70 million to begin a new program within Space Research and Technology, the Civil Space Technology Initiative (CSTI). This effort will support research in a wide variety of technology areas including space-based propulsion, automation

and robotics and control of large structures, which are crucial to the nation's ability to provide efficient, reliable access to space. CSTI will involve researchers from all sectors, industry, universities and the Federal government, and represents a combination of augmentations to ongoing efforts as well as totally new activities.

Table J-7 provides the details of NASA's R&D funding.

Table J-7. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity	1986 actual	1987 estimate	1988 estimate
OBLIGATIONS			
Conduct of R&D:			
Space station.....	173	374	663
Space transportation systems capability.....	357	562	551
Space science and applications.....	1,473	1,599	1,455
Commercial programs.....	21	49	53
Transatmospheric research and technology.....		43	65
Aeronautical research and technology.....	292	315	306
Agency-wide support activities:			
Space research and technology.....	149	182	238
Safety, reliability and quality assurance.....	7	9	16
Tracking and data acquisition.....	15	18	18
Research and program management.....	933	1,034	1,134
Total conduct of R&D.....	3,420	4,185	4,498
Total conduct of basic research, included above.....	(917)	(1,069)	(1,016)
R&D facilities.....	276	325	420
Total obligations.....	3,696	4,510	4,918
OUTLAYS			
Conduct of R&D.....	3,432	3,711	4,159
R&D facilities.....	299	294	384
Total outlays.....	3,731	4,005	4,543

DEPARTMENT OF ENERGY

The R&D programs of the Department of Energy include: a *National Defense Program* related to the development and testing of nuclear weapons; a *General Science Program* of basic research in high energy physics and nuclear sciences; and an *Energy Program* focused on longer-term R&D in support of energy technology development. Table J-8 provides summary information on the funding of these programs.

Obligations for the conduct of R&D by the Department are estimated to total \$5.0 billion in 1988, an increase of \$215 million from 1987. Obligations in 1988 for R&D facilities, including the construction or upgrading of general purpose laboratories and other research support facilities, will amount to \$848 million.

Obligations for the conduct of basic research, included in the total for the conduct of R&D, are estimated to be \$1,133 million in 1988, an increase of \$50 million over 1987. Within the basic research total, funds are provided to continue or initiate a number of major projects, in both the energy program and the general science program, that will enhance the nation's capability in basic research and help contribute to global competitiveness.

The *National Defense Program* supports the continued research, development and testing of nuclear weapons. It also supports the development of improved naval propulsion reactors, technologies for monitoring nuclear weapons treaties, and methods for safeguarding nuclear materials. In addition, R&D efforts will continue in developing methods for the safe storage and disposal of radioactive wastes resulting from weapons production. Obligations for the conduct of R&D by the national defense program will increase from \$2.4 billion in 1987 to \$2.5 billion in 1988. Increased funding for conduct of R&D supports new and ongoing Department of Defense requirements including isotope separation techniques, increased weapons testing, and increased research in the basic physics of nuclear weapons. Increases in the advanced weapons concepts activities, which support the Strategic Defense Initiative (SDI), will focus on investigations of Nuclear Directed Energy Weapons (NDEW) to assess the Soviet NDEW capability to threaten either a nuclear or non-nuclear strategic defense system. SDI funding will increase from \$349 million in 1987 to \$481 million in 1988.

The *General Science Program* supports basic research in high energy and nuclear physics. A proposed increase of \$48 million, to \$623 million, in 1988 for the conduct of basic research will enhance support for experimental efforts to understand the basic constituents of matter and energy and the forces that govern their interaction. Obligations for R&D facilities will also increase \$47 million to \$189 million.

The 1988 budget request will provide for:

- increased utilization of existing accelerator facilities, including the first full year of operation of the Stanford Linear Collider at SLAC; the Tandem/Alternating Gradient Synchrotron at Brookhaven National Laboratory and Tevatron I at Fermilab;
- continued construction of the Central Computing Facility project at Fermilab, the Accumulator/Booster Ring upgrade at the Brookhaven Alternating Gradient Synchrotron and the advanced nuclear physics electron accelerator facility at Newport News, Virginia; and
- continued support for advanced accelerator and detector research and development activities related to next-generation high energy and nuclear physics accelerators.

The *Energy Program* funds basic science and engineering research underlying both nuclear and non-nuclear technologies, R&D to support development of specific energy technologies, and research on the environmental and human health effects of energy production technologies. Energy program obligations for the conduct of R&D will increase by \$14 million over the 1987 level to \$1,862 million in 1988. This increase consists of increases for basic supporting research and the clean coal technology program, offset by proposed reductions in support for nearer-term non-nuclear energy technology programs. Obligations for R&D facilities in this program will be \$169 million, nearly the same as in 1987.

In the *basic energy sciences*, funding is proposed at a level of \$479 million in 1988, an increase of \$32 million over 1987, for the conduct of research in such fields as nuclear science, chemistry, engineering, materials science, applied mathematics, biology, and the geosciences. The program provides the fundamental scientific and technical base for future advances in both nuclear and non-nuclear technology development. In addition, the program provides support for the operation of several major national facilities that are used by researchers from industry, universities and national laboratories. These include the National Synchrotron Light Source (NSLS) at the Brookhaven National Laboratory, the Intense Pulsed Neutron Source (IPNS) facility at Argonne National Laboratory, and the Combustion Research Facility at Sandia National Laboratory.

The 1988 budget continues to provide support for construction of the Center for Advanced Materials and the 1-2 GeV synchrotron at Lawrence Berkeley Laboratory and the experimental detection halls at the Los Alamos Neutron Scattering Center. In addition, construction of a 3 GeV injector for the SPEAR Storage Ring at Stanford will be initiated to provide the Stanford Synchrotron Radiation Laboratory with an independent light source.

Funds in 1988 are also provided for an additional Class VII computer to handle the backlog of computational needs of all the basic research programs of DOE and for R&D activities related to advanced synchrotron and neutron facilities required for future state-of-the-art engineering and science research. Funds to maintain operations of existing research facilities at the 1987 level are also included in the 1988 Budget.

A major expansion in the *Energy Program* for 1988 involves the *clean coal technology* program. The goal of this program is to demonstrate technologies to burn coal more cleanly. The Department solicits proposals from the private sector for 50 percent cost-shared commercial-scale demonstrations of clean coal technologies. Typical examples of such technologies include: advanced coal cleaning techniques, alternate combustion technologies, preparation of

clean coal-based fuels, and post-combustion cleanup systems. The demonstrations are targeted closely to the recommendations of the U.S. and Canadian Special Envoys' Report on Acid Rain. Obligations for the program in 1988 will be \$351 million, an increase of \$292 million over 1987.

The 1988 budget will continue the redirection of the on-going non-nuclear R&D programs to limit federal support to longer-term generic research and place greater reliance on the private sector for support of nearer-term technology development. To increase the involvement of the private sector in the direction and management of industry-based R&D programs, \$17 million will be available in 1988 to support DOE participation in cooperative R&D ventures in broad areas of generic technology development. Obligations for the conduct of R&D in the technology base programs of the *fossil*, *solar/renewables* and *conservation* programs are expected to be \$283 million in 1988, a decrease of about \$213 million from 1987.

Funding proposed for the conduct of *fossil* related R&D and associated facilities will be \$162 million in 1988, a decrease of \$100 million from 1987. The 1988 budget is focused on research to improve technologies for utilizing coal and for extracting oil and gas from unconventional sources. Support in the technology base program continues to be provided in such areas as the chemistry of coal conversion, environmental controls, and combustion research.

Research in support of *solar and other renewable energy* technologies, proposed at a level of \$103 million, will emphasize longer term, technology base R&D in areas such as photovoltaics, solar thermal energy, biofuels, wind and geothermal energy, electrical energy systems, and energy storage. The total request in 1988 for the *energy conservation* R&D program is \$75 million and includes research in buildings and community systems, industry, and transportation.

The 1988 budget continues to provide for a broad program of research in nuclear *fission* and *fusion* energy technologies. Total obligations for these R&D programs will be about \$680 million in 1988, approximately the same as the 1987 level. Conduct of R&D will total approximately \$600 million, and funding for related facilities will be \$79 million.

In the *fission* program, obligations of \$334 million are estimated for the conduct of R&D in 1988, the same level as in 1987. Total obligations for R&D facilities in 1988 will be \$42 million. The nuclear fission R&D program will continue to shift efforts from the advanced civilian reactor program toward R&D on reactor concepts that can meet space and military nuclear power requirements. The restructured program, while serving national security interests, will also maintain a technical and industrial base for any future deployment of advanced nuclear technologies in the commercial

sector. The fission R&D program will also seek to resolve technical issues associated with the technology of nuclear waste storage and consequent environmental impacts.

In the *magnetic fusion* program, funding of \$346 million is proposed for the conduct of R&D, the same level as in 1987. In 1988, the fusion program will focus on the development of the toroidal magnetic confinement system by supporting the continued operation of Princeton's large tokamak test reactor (TFTR), of GA Technologies' Doublet-III-D machine, and of the Oak Ridge National Laboratory's ATF torsatron. Fabrication of three smaller toroidal devices also will continue in 1988: a reversed field pinch machine (RFP) at Los Alamos, a compact toroid called a field reversed configuration (FRC) experiment, and a high field high density tokamak (Alcator C-MOD) at Massachusetts Institute of Technology (MIT). Two new toroidal experiments will be initiated in 1988, the construction of a Compact Ignition Tokamak (CIT) which is designed to prove a plasma can ignite and burn, and a novel heating experiment using a free electron laser which could make steady state tokamak operation possible. Other research that supports the President's Geneva Initiative on expanded cooperation with the Soviets in fusion research will also continue in 1988.

Finally, the *energy program* supports R&D to better understand the biological and environmental effects of energy production and use. The level of funding for the *biological and environmental* research program will be \$218 million in 1988, an increase of \$23 million or 12 percent above 1987. The biological program emphasizes the health effects of radiation, the use of radiation in medical diagnosis and therapy, and generic biological research related to radiation and other cellular traumas. A new initiative in 1988 will be the beginning phase of a study to "map the human genome". Results from this research hold the promise for enabling the structure and function of genes to be decoded and for detecting changes in human DNA caused by exposure to toxic pollutants. The environmental program supports research in areas related to energy technologies, such as atmospheric processes involved in acid rain formation and deposition and carbon dioxide-induced climatic effects. A major thrust in 1988 will be an expanded program of radon research. Recent information indicates that potential exposures to radon gas in residential structures, and the number of people so exposed, may be substantial. The main themes of the preliminary stages of this new program will be investigations of sources and health effects of radon and a survey of factors affecting possible methods of mitigating radon levels in indoor environments. Funding in 1988 for radon-related, acid rain-related, and carbon dioxide-related research is nearly \$34 million, an increase of 47 percent over 1987.

Table J-8 provides the details of funding for the Department of Energy.

Table J-8. DEPARTMENT OF ENERGY

(In millions of dollars)

Type of activity	1986 actual	1987 estimate	1988 estimate
OBLIGATIONS			
Conduct of R&D:			
National defense program.....	2,248	2,378	2,531
General science program.....	517	575	623
Energy program.....	1,943	1,848	1,862
Total conduct of R&D.....	4,708	4,801	5,016
Total conduct of basic research, included above.....	(964)	(1,084)	(1,133)
R&D facilities.....	750	744	848
Total obligations.....	5,459	5,545	5,864
OUTLAYS			
Conduct of R&D.....	4,705	4,819	4,863
R&D facilities.....	784	820	793
Total outlays.....	5,489	5,639	5,656

DEPARTMENT OF HEALTH AND HUMAN SERVICES

The Department of Health and Human Services will obligate a total of \$6.3 billion in 1988 for the conduct of R&D. Within this total, funding for basic research is estimated to be \$3.7 billion. Direct obligations for R&D facilities will total \$6 million in 1988, with Federal overhead payments providing additional funds which can be used to replace or modernize existing R&D facilities.

Health.—About 90 percent of the Department's funds for the conduct of R&D will be obligated by the National Institutes of Health for biomedical research to advance the nation's capabilities for the prevention, diagnosis, and treatment of disease. Several other agencies within the Department—the Alcohol, Drug Abuse, and Mental Health Administration, the Food and Drug Administration, the Centers for Disease Control, the Health Resources and Services Administration, the Health Care Financing Administration, and the Office of the Assistant Secretary for Health—also support health-related research.

The *National Institutes of Health (NIH)* consist of 12 separate Institutes which will obligate \$5.6 billion in 1988 for the conduct of R&D, a slight increase over 1987. NIH will fund about 19,100 research project grants, about 560 centers, and about 10,900 research trainees in 1988. Continued emphasis will be given to support of basic research in 1988. About 60 percent, or \$3.4 billion, of NIH's proposed R&D budget will support basic research.

Among the continuing R&D activities to be supported by NIH are:

- continuation of research and cooperative clinical trials on the Acquired Immune Deficiency Syndrome (AIDS); and
- clinical research with emphasis on medical intervention in the disease process, including prototype development and refinement of products, techniques, processes, methods, and practices.

The *Alcohol, Drug Abuse and Mental Health Administration (ADAMHA)* conducts studies on the causes, prevention and treatment of alcohol and drug abuse and on mental disease and neurological disorders, with emphasis on improving knowledge of effective prevention of these public health problems.

The 1988 budget continues to emphasize research into drug abuse, and stabilizes ADAMHA's extramural research programs in biomedical, behavioral and clinical areas by supporting about 1,600 research project grants per year. Of the \$569 million in 1987 obligations, about \$30 million will be available through 1988 for drug abuse research. ADAMHA will obligate \$491 million in 1988.

The *Food and Drug Administration* supports research relevant to its mission of regulating food, drugs, biologics, medical devices and radiological products. In 1988, obligations for these activities are estimated at \$87 million.

The *Centers for Disease Control* support studies on the epidemiology and control of communicable diseases and on health promotion and disease prevention. In 1988, obligations for these activities are estimated at \$56 million.

Other Health Related Agencies within the Department support research in areas such as the efficacy and cost-effectiveness of emerging health care technologies; the effect of increased numbers of physicians on access to care and health care costs; and, survey methods and techniques for analysis of health statistics. This support is provided through programs of the Health Resources and Services Administration, the Office of the Assistant Secretary for Health and the Health Care Financing Administration.

Human services.—Most of the 1988 funding for human services R&D activities administered by HHS is included in the \$2.2 billion generic appropriation request for the Office of Human Development Services. Depending on Congressional priorities within this level of effort, the proposed budget could support a variety of development and social services research on the Head Start program, the elderly, child abuse and neglect, day care systems, family and community support systems, and foster care and adoption assistance.

Table J-9 provides details of the R&D funding of the Department of Health and Human Services.

Table J-9. DEPARTMENT OF HEALTH AND HUMAN SERVICES—RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity and organizational units	1986 actual	1987 estimate	1988 estimate
OBLIGATIONS			
Conduct of R&D:			
Health:			
National Institutes of Health	5,004	5,519	5,573
Alcohol, Drug Abuse, and Mental Health Administration	396	569	491
Food and Drug Administration.....	79	84	87
Centers for Disease Control.....	52	59	56
Health Care Financing Administration.....	30	28	36
Office of the Assistant Secretary for Health.....	18	23	23
Health Resources and Services Administration.....	8	9	9
Subtotal, Health.....	5,588	6,290	6,274
Human Services:			
Social Security Administration.....	6	12	12
Family Support Administration	3	3	3
Office of Human Development Services ¹	58	41
Departmental Management.....	6	6	5
Subtotal, Human Services.....	73	63	20
Total conduct of R&D.....	5,661	6,353	6,294
Total conduct of basic research, included above	(3,335)	(3,663)	(3,712)
R&D facilities.....	41	58	6
Total obligations.....	5,702	6,411	6,300
OUTLAYS			
Conduct of R&D.....	5,504	6,012	6,187
R&D facilities.....	33	38	29
Total outlays.....	5,536	6,051	6,216

¹ No 1988 detail available; awaiting Congressionally-defined priorities within the requested level of effort.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) supports primarily basic research in all disciplines through grants to scientists and engineers in academic institutions. NSF support is particularly important because it complements the R&D programs of other agencies and assists in balancing Federal support for promising research across all fields of science and engineering.

The 1988 NSF budget provides \$1.7 billion in obligations for the conduct of R&D, an increase of \$238 million or about 17 percent above 1987. Within this total, support for basic research will also increase by about 17 percent.

For 1988, emphasis will be placed on three major themes:

- *Education and Human Resources* (\$273 million, a 50 percent increase over 1987): will provide increased support for the NSF Graduate Fellowship Program (200 additional Fellows, for a total of about 760 new awards) and for the Presidential

Young Investigators program (200 new awards, for a total of about 900 new awards). A major increase for undergraduate programs will provide important new opportunities for faculty enhancement, and student research participation as well as providing for much needed instrumentation. There will also be a significant enhancement of support to encourage the participation of underrepresented groups in scientific and engineering research.

- *Basic Science and Technology Centers and Groups* (\$529 million, an 18 percent increase over 1987): will provide increases for ongoing efforts such as the Engineering Research Centers (ERCs) and the Advanced Scientific Computing Centers (ASCs), as well as the initiation in 1988 of a new program, Basic Science and Technology Centers. This new program will expand the concept of the ERCs to fields of science such as biology, materials science, and computer and information sciences. Like the ERCs, these new centers will be university-based, multidisciplinary, will incorporate strong involvement by the private sector and state and local governments, and will provide important opportunities to train future scientists and engineers. It is expected that perhaps as many as 15 such centers will be started in 1988. In addition to the centers, a number of research areas, including global geosciences and biotechnology, will be the focus for research by a number of coordinated groups.
- *Strengthened Disciplinary Programs and Facilities* (\$1.1 billion, an increase of 10 percent over 1987): will provide for a continued steady improvement of NSF's traditional broad support for high-quality research programs and specialized research facilities across a wide spectrum of disciplines. A high priority will be given to increasing grant sizes and enhancement of support for emerging fields of high scientific opportunity (e.g., storm-scale meteorology, cognitive sciences, parallel processing). In addition, specialized research facilities including the Very Long Baseline Array radio-telescope (VLBA), the Cornell Electron Storage Ring (CESR), the National Center for Atmospheric Research (NCAR) and the national astronomy centers will receive priority attention. The FY 1988 budget also provides funds for the U.S. Antarctic Program (USAP) to lease a new icebreaker to support research as well as operations in the Antarctic. The USAP is managed by NSF and is the principal expression of U.S. presence on the Antarctic continent.

DEPARTMENT OF AGRICULTURE

The Department of Agriculture supports research and development in several disciplines related to agriculture and forestry to ensure the continued high productivity of U.S. agricultural and forest lands.

Obligations of the Department for the conduct of research and development are expected to total \$961 million in 1988, compared to the \$978 million in 1987. Of the total, \$454 million will support basic agricultural research, maintaining the 1987 estimated level. The Department's 1988 Budget for research and development is highlighted below by major bureau.

The *Agricultural Research Service* expects to obligate \$527 million in 1988 to conduct basic and applied research in plant and animal productivity; commodity conversion and delivery; soil and water conservation; and integration of systems. This is an increase of \$37 million in obligations over 1987. In 1988, increased emphasis will be placed on basic research in plant germplasm and biotechnology to improve the profitability and competitiveness of U.S. agriculture. Research will also be directed at reducing fat in consumer meats.

The *Cooperative State Research Service (CSRS)* estimates that \$238 million will be obligated in 1988. CSRS supports research on agriculture and forestry through grants to land-grant colleges. Also, within CSRS, the Competitive Research Grants program funds basic research in biotechnology, plant and animal science, pest science, and human nutrition.

The *Forest Service* estimates that \$122 million will be obligated for research and development in 1988. This represents a decrease from the \$126 million obligated in 1987. The long-range goal of forestry research is to provide the information needed to manage and protect forest and range land resources, and to gain maximum economic and social benefits from their use.

Other Departmental programs will obligate approximately \$75 million for R&D in 1988, covering a broad spectrum of research activities, such as research in agricultural economics, international agricultural cooperation, and statistical reporting.

DEPARTMENT OF COMMERCE

The Department of Commerce undertakes research primarily in ocean science and engineering, meteorology and weather forecasting, and in the maintenance of measurement standards to support science and industry.

Obligations for the conduct of R&D by the Department in 1988 are estimated at \$333 million, a decrease of \$63 million from 1987. This reflects reduced levels of support by the National Oceanic and Atmospheric Administration for applied research, that is more ap-

propriately the responsibility of state and local governments or the private sector.

National Oceanic and Atmospheric Administration (NOAA).—NOAA obligations for the conduct of research and development will decrease from \$277 million in 1987 to \$215 million in 1988 as a result of greater reliance on support from the private sector and state and local governments, and elimination of lower priority research in such programs as Seafloor Spreading Center Research, National Undersea Research Program, National Sea Grant College Program, and some programs of the National Marine Fisheries Service. Acid rain research and R&D to support the Pacific Salmon Treaty will be maintained.

National Bureau of Standards (NBS).—NBS conducts research aimed at maintaining and improving a system of measurement required to support the nation's industrial and scientific endeavors. In 1988, NBS is expected to obligate \$106 million for the conduct of R&D. This represents an increase of \$6 million from 1987. Funding will increase to support development of measurements and standards for process and quality control, high-performance composites, fiber optics, bioprocess engineering and the Cold Neutron Research Facility. Funding for several programs, including fire and building research, will be reduced because such research can and should appropriately be supported by other sectors of the economy.

Other Commerce R&D Activities.—Funding for smaller R&D programs in the Department, which include those in General Administration, the Bureau of the Census, the Economic Development Administration, and the National Telecommunications and Information Administration, are proposed at \$12 million in 1988, a decrease of \$7 million from the 1987 level.

DEPARTMENT OF THE INTERIOR

The R&D activities of the Department of the Interior principally derive from its broad-ranging responsibilities for management of the nation's natural resources, including developing energy and mineral resources, and restoring and preserving wildlife habitats. R&D programs also serve the needs of other Federal agencies and the private sector.

Obligations for the conduct of R&D for the Department of the Interior for 1988 are estimated at \$364 million. This represents a decrease of \$2 million from the 1987 level.

About 92 percent of the Department's 1988 funds for the conduct of R&D will be obligated by the Geological Survey (\$212 million), Fish and Wildlife Service (\$51 million), and the Bureau of Mines (\$71 million). Highlights of the 1988 research objectives of these and other departmental programs are described below.

The *Geological Survey* undertakes research on the extent, distribution, and character of the nation's water and other natural resources and on the geologic processes, structures, and hazards that affect the development and use of the land and physical environment. For 1988, obligations will increase by \$5 million, to a total of \$212 million.

Research in 1988 will be directed toward:

- accurate appraisals of mineral resources and new improved methods of mineral exploration;
- development of basic data on geologic principles and processes;
- improvement of the scientific basis for appraisal and evaluation of water resources; and
- development and application of new technologies, including remote sensing, to prepare cartographic information.

The *Fish and Wildlife Service* supports research in the Service's laboratories and field stations and cooperative efforts with state fish and game departments. It also provides Federal aid to states for research on restoration of fish and wildlife resources. This research provides basic biological information about species numbers, population dynamics, ecological relationships, and habitat requirements. Obligations will total \$51 million in 1988.

The Fish and Wildlife Service will support research activities concerned with:

- the habitats of waterfowl, migratory and non-migratory birds, and mammals;
- the status and distribution of endangered and threatened species;
- impact of broad-scale environmental changes on fish and wildlife populations and habitat; and
- diseases of freshwater and anadromous fish.

The *Bureau of Mines* conducts basic and applied research across the minerals cycle to improve understanding of the principles of mining and minerals processing and to reduce associated health hazards. Obligations for the conduct of R&D are expected to decrease by \$7 million to \$71 million in 1988. This decrease in obligations is the result of proposed reductions in applied research, particularly in projects which are more appropriate for support by non-Federal sources. The 1988 budget reflects continued emphasis on strategic and critical minerals R&D activities and stresses:

- long-range, high-risk research in extractive metallurgy technology;
- development of domestic source substitutes for imported strategic and critical minerals;
- health-related research on the proper quality and quantity of air flow in underground mines; and

- long-term, generic research on mine disaster prevention, ground control, industrial hazards, explosives, and systems engineering.

Other Departmental Programs expect to obligate about \$30 million in 1988, a decrease of about \$3 million from 1987.

DEPARTMENT OF TRANSPORTATION

The R&D program of the Department of Transportation is oriented toward providing the information and new technology needed for its own operational (e.g., air traffic control) programs and for regulatory (e.g., automotive and aircraft safety standards) programs. Obligations for the conduct of research and development by the Department are estimated at \$290 million for 1988, a decrease of \$19 million from 1987.

The *Federal Aviation Administration* (FAA) is expected to obligate \$160 million in 1988. This funding level is consistent with the National Airspace System Plan. Major initiatives include continued development of a new ATC automation system, modernization of the communications system, development of radars for detection and tracking of severe weather, and completion of programs which will determine the future mix of navigation systems. Other work includes Automated En Route Air Traffic Control (AERA); aircraft safety, which includes explosive or sabotage detection, research into biomedical factors related to aircraft accidents, injuries and fatalities; and minimization of environmental consequences of flight such as noise reduction and control, and reduction and control of aircraft engine emissions.

The *National Highway Traffic Safety Administration* will obligate \$27 million for motor vehicle and highway safety research, and demonstrations including safety belt usage, alcohol countermeasures, and emergency medical services.

The *Urban Mass Transportation Administration* (UMTA) is expected to obligate \$11 million to conduct research, training, and human resources programs in all phases of urban mass transportation which will promote private sector involvement in mass transportation services or contribute toward meeting total urban transportation needs at minimum costs. In addition, UMTA supports interdisciplinary research at colleges and universities including training of personnel to conduct further research or to obtain employment in urban mass transportation planning, construction, operation or management.

The *Federal Highway Administration* will obligate \$52 million to continue research programs in highway planning, design, construction, and maintenance to ensure an effective and efficient highway system. Research will also be directed toward identifying and correcting impediments to highway safety and improving truck safety.

The *Federal Railroad Administration* will obligate \$10 million to support R&D efforts to enhance railroad safety.

The *U.S. Coast Guard* will obligate \$21 million to support research to maintain and improve search and rescue systems, environmental protection, marine safety, aids to navigation, the enforcement of laws and treaties, and activities affecting all Coast Guard missions.

The *Research and Special Programs Administration* will obligate \$2 million for R&D in hazardous materials, pipeline safety, radio-navigation, transportation statistics, and emergency transportation.

The *Office of the Secretary* will obligate \$8 million for broad-based policy research on domestic and international transportation issues of importance to the nation and research in support of licensing and the promotion of expendable launch vehicles.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) conducts research and development in support of its regulatory responsibilities to protect human health and the environment. The 1988 budget proposes \$346 million in total obligations, representing an increase of 5 percent above 1987. The 1988 budget emphasizes: (1) a continued commitment to acid rain research to provide a scientifically valid framework for sound policy decisions; (2) enhanced research in air toxics and new efforts to understand the phenomena of stratospheric ozone depletion and global climate change; and (3) providing the scientific information necessary to support the Agency's hazardous waste and Superfund activities.

The acid rain/energy research program will continue to support development of more reliable information upon which mitigation decisions can be made. The program directs basic research in areas identified by the Interagency Task Force on Acid Precipitation to provide enhanced data on the physical and chemical mechanisms governing the acid rain phenomenon.

The *air research* program will be expanded in 1988 to include studies to determine the effects of ozone on tree growth; development of manuals for the prevention and cleanup of accidental releases of high hazard chemicals; new studies to characterize and reduce emissions from incineration of municipal waste; development of advanced monitoring methods to characterize complex mixtures of pollutants; and development of risk assessment methods for health endpoints other than cancer. EPA will also participate in the next National Health and Nutrition Examination Survey (NHANES) as part of a multi-year interagency effort.

The pesticides program will continue to support development of methods to detect the presence of and exposure to pesticides in groundwater, and to assess management strategies to prevent such

contamination. Pesticides research will also support studies on the effects of bioengineered pesticides.

The toxic substances research program will continue to address hazards associated with products of biotechnology, as well as to support ongoing engineering efforts that focus on the development and evaluation of release and control methods for new and existing chemicals.

The hazardous waste research program will address several areas of study needed to implement regulations required by the 1984 RCRA Amendments.

The Superfund research program will be expanded under the new Amendments to provide technical support in conducting clean-ups and enforcement actions at Superfund sites. Field demonstrations of newly developed technologies for cleaning up Superfund sites will be initiated and a new health research program will be established to assess the risks of and monitor exposure to hazardous substances.

The drinking water research program will examine the health effects of complex chemical mixtures and will provide technology and monitoring data to support the development of drinking water standards. The water quality research program will continue to provide scientific data needed to support a water quality-based approach to pollution control as well as develop data to support the ocean disposal, estuarine and Great Lakes programs.

VETERANS' ADMINISTRATION

The Veterans' Administration (VA) conducts and administers a program of medical, rehabilitation, and health services research designed to improve the quality and increase the effectiveness of health care for the veteran. In 1988, the VA will obligate \$214 million for the conduct of R&D. This is an increase of \$3 million above 1987.

The VA intramural biomedical research program covers a wide range of medical problems, with special emphasis on Agent Orange, aging, alcoholism, post-traumatic stress, the health problems of female veterans and former prisoners of war, schizophrenia, spinal cord injury and tissue regeneration.

Rehabilitation research focuses on the problems of the disabled veteran, the amputee and the paralyzed, and develops sensory aids for impaired vision and hearing. This work brings the latest electronic and computer technology to bear on problems of prosthetics, orthotics, wheelchair design, and spinal cord injury (including functional electrical stimulation of muscles in paralyzed limbs).

Health services research is designed to help health care professionals and managers to improve the effectiveness, economy, and accessibility of health care services provided to the veteran. Re-

search in this area deals with such areas as aging and preventive medicine.

AGENCY FOR INTERNATIONAL DEVELOPMENT

Research and development activities of the Agency for International Development (AID) consist mainly of applied research to solve specific problems associated with basic human needs and social and economic research aimed at improving U.S. and host-country understanding of the barriers to development. Programs under AID reflect the administration's recognition of the importance of R&D in addressing the problems faced by the Third World. Over the years, AID has provided substantial support to research efforts undertaken by U.S. universities and international research centers such as the International Rice Research Institute in the Philippines.

Obligations by AID for the conduct of R&D are estimated at \$233 million for 1988, an increase of \$16 million over 1987.

AID will continue to support research aimed at improving agricultural production capability, with an emphasis on efforts to overcome the mounting food crisis in Third World nations. R&D funds will also be devoted to two other critical problems: population growth, emphasizing methods of controlling increasing population growth rates in the developing countries, and energy supply, emphasizing renewable and nonconventional energy sources critical for development to proceed.

Significant research efforts are also being pursued in two other promising areas: oral rehydration therapy and a malaria vaccine. The former holds the promise of significantly reducing the incidence of child mortality associated with diarrheal diseases, currently estimated to claim the lives of over 1 million children annually. Similarly, AID-supported research on a malaria vaccine may lead to a breakthrough in controlling a disease which currently infects some 200 million people worldwide and is the leading cause of death in Third World nations.

OTHER AGENCY PROGRAMS

An additional 9 departments and agencies (listed in table J-2, footnote 1) will obligate an estimated \$463 million in 1988, for the conduct of R&D, a decrease of about 10 percent below the 1987 level. Obligations by these agencies amount to less than 1 percent of all federally-funded programs in R&D. The programs of these agencies, like those of other agencies discussed above, are closely related to serving the agencies' missions.

Among the agencies in this category that expect to increase their obligations for R&D in 1988 are the Smithsonian Institution, the

U.S. Army Corps of Engineers, and the Departments of Labor, Housing and Urban Development, and Treasury.

Table J-10 provides information on the long-term trends in Federal funding for the conduct of R&D.

Table J-10. TRENDS IN CONDUCT OF R&D

(Obligations in billions of dollars)

Year	Defense ¹	All other	Total	Basic research ²
1960.....	6.1	1.5	7.6	0.6
1961.....	7.0	2.1	9.1	0.8
1962.....	7.2	3.1	10.3	1.0
1963.....	7.8	4.7	12.5	1.2
1964.....	7.8	6.4	14.2	1.3
1965.....	7.3	7.3	14.6	1.4
1966.....	7.5	7.8	15.3	1.6
1967.....	8.6	7.9	16.5	1.8
1968.....	8.3	7.6	15.9	1.8
1969.....	8.4	7.2	15.6	1.9
1970.....	8.0	7.3	15.3	1.9
1971.....	8.1	7.4	15.5	2.0
1972.....	8.9	7.6	16.5	2.2
1973.....	9.0	7.8	16.8	2.2
1974.....	9.0	8.4	17.4	2.4
1975.....	9.7	9.3	19.0	2.6
1976.....	10.4	10.4	20.8	2.8
1977.....	11.9	11.6	23.5	3.3
1978.....	12.6	13.2	25.8	3.7
1979.....	13.6	14.5	28.1	4.2
1980.....	15.1	14.7	29.8	4.7
1981.....	17.8	15.3	33.1	5.0
1982.....	22.1	14.3	36.4	5.5
1983.....	24.5	13.9	38.4	6.4
1984.....	28.3	14.9	43.2	7.0
1985.....	33.4	16.1	49.5	7.8
1986.....	36.5	16.2	52.6	8.1
1987 (estimate).....	39.9	17.7	57.6	8.8
1988 (estimate).....	46.6	18.2	64.8	9.1

¹ Includes military-related programs of the Departments of Defense and Energy.

² Included in totals for conduct of R&D.

SPECIAL ANALYSIS J

RESEARCH AND DEVELOPMENT

This analysis covers the funding of research and development across all agencies with R&D programs of \$10 million or more. It consists of two sections. The first highlights the R&D policies and trends in the 1989 budget. The second describes in more detail the R&D programs of 12 agencies whose R&D obligations individually exceed \$150 million. In the aggregate, these agencies fund over 99 percent of total Federal R&D.

PART I. HIGHLIGHTS

In 1989, total Federal obligations for research and development, including R&D facilities, are estimated at \$64.6 billion, an increase of about \$2.7 billion or 4 percent above the 1988 estimated level of \$61.9 billion as shown in table J-1. Support for the conduct of basic research, included within this total, is estimated to increase by 6 percent, from \$9.7 billion in 1988 to \$10.3 billion in 1989.

The Federal Government supports research and development:

- to meet the direct needs of the Federal Government where the supporting agencies are also the principal users of the results of the R&D. Examples include R&D for national security and research to support regulatory activities; and
- to assist in meeting broad national needs, particularly where the private sector lacks sufficient incentives for adequate investment to assure that the scientific and technological foundation is in place to support long-term economic growth and continued improvement in the quality of life for all citizens. Examples of such investments are those directed toward basic research across all fields of science and engineering, and agricultural and health-related R&D.

The ability of the Nation to meet global competition, to provide for the national security, and to improve the quality of life for all citizens depends in part on national investments in science and technology. In FY 1988 national spending for R&D is projected to total about \$132 billion, a real increase of about 3 percent over 1987. Of this amount, about \$65 billion is expected from Federal spending, \$63 billion from industry, and the balance from universities, colleges and other non-profit organizations. The growth rate between 1987 and 1988 is projected to be the lowest in this decade, and is attributable both to tightening Federal budgetary con-

straints, and, in the private sector, to corporate restructurings and other factors. However, the rate of growth in national R&D spending is still expected to show a real increase above inflation.

For 1989, the budget provides increased Federal support for R&D to meet key national needs. The budget also provides increased support for basic research, particularly interdisciplinary research at universities, to help generate the new knowledge necessary for continued technological innovation and to help assure the future availability of high-quality scientists and engineers.

The Federal Government will also continue to encourage and facilitate the transfer of technology and new knowledge from universities and Federal laboratories to the private sector. In addition to technology transfer, industry has also benefitted from other Federal actions that help to create a climate that encourages increased private sector support for R&D. Such actions have included revisions of policies on ownership of patents and other intellectual property to provide incentives for innovation, revisions of antitrust laws to encourage joint industrial R&D efforts, and revisions of the tax code (including a 1989 proposal to make the R&D tax credit permanent) to encourage increased R&D expenditure.

Even in the context of the Bipartisan Budget Agreement which places severe but necessary fiscal constraints on the budget as a whole, the 1989 budget reflects the continued high priority the Administration places on R&D that is appropriate for Federal support. The 1989 budget provides significant increases for R&D programs in key agencies including:

- selected R&D programs of the Department of Defense such as the Strategic Defense Initiative and the Advanced Tactical Fighter;
- most of the R&D programs of the National Aeronautics and Space Administration including the Space Station, Project Pathfinder, and other space science and technology programs;
- basic research support by the National Science Foundation including the establishment of Science and Technology centers;
- support in the Department of Energy for initiation of construction of the Superconducting Super Collider (SSC), and for a 5-year, \$2.5 billion clean coal technology demonstration program; and
- Biomedical and AIDS R&D.

At the same time, the 1989 budget continues to propose reductions in programs that are not an appropriate Federal responsibility and which should be left to the states or the private sector for needed investments. These include large reductions in the energy technology programs of the Department of Energy, as well as elimination of selected programs of the Department of Commerce (e.g.,

the Sea Grant program), and certain research activities of the Department of Interior (e.g., the Mineral Institutes program).

Table J-1. TOTAL FEDERAL FUNDING FOR CONDUCT OF R&D AND RELATED FACILITIES

(In billions of dollars)

	Obligations			Outlays		
	1987 actual	1988 estimate	1989 estimate	1987 actual	1988 estimate	1989 estimate
Conduct of R&D	56.1	60.0	62.5	52.9	54.2	59.3
R&D facilities	1.7	2.0	2.1	1.5	1.8	1.9
Total	57.8	61.9	64.6	54.3	56.0	61.2

CONDUCT OF RESEARCH AND DEVELOPMENT

The budget for 1989 includes \$62.5 billion in obligations for the conduct of R&D, an increase of \$2.6 billion or 4 percent over 1988. The conduct of R&D associated with national defense (i.e. military-related R&D programs of the Departments of Defense and Energy) makes up about 65 percent of the total Federal spending on R&D. In 1989, however, civilian R&D will grow at a faster rate than defense-related R&D, due primarily to the constraints imposed by the Bipartisan Budget Agreement. The limitations on defense spending imposed by this agreement necessitated major reductions across the board in defense programs including R&D. Limitations were also imposed on domestic discretionary spending (which includes all civilian R&D). However, even with this constraint, the Administration continues to assign a high priority to support for appropriate R&D. Highlights of the proposed programs of the six major R&D agencies, which account for 96 percent of the obligations for the conduct of R&D by the Federal Government, are presented below.

- **Department of Defense (DOD).**—Obligations for the conduct of R&D by DOD are estimated at \$38.8 billion for 1989, an increase of \$888 million (about 2 percent) above 1988. While funding for R&D is relatively constant from 1988 to 1989, it does allow growth for some important programs, including the Strategic Defense Initiative and the Advanced Tactical Fighter. There is also an increase for the joint DOD-NASA program to support development of the National Aerospace Plane.
- **Department of Energy (DOE).**—Obligations for the conduct of R&D by the Department of Energy are estimated to be \$5.2 billion, an increase of \$95 million from 1988. Funding for the National Defense Program will remain comparable to the 1988 level. High Energy and Nuclear Physics R&D in the General Science Program will increase from \$625 million in

1988 to \$704 million in 1989. Included in this total are funds to enhance support for long-term basic research and to enhance substantially the R&D effort on the superconducting magnets and other technical components required for the Superconducting Super Collider accelerator facility and to increase the levels of operation of all major on-line high energy and nuclear physics accelerators. Obligations for Energy Programs will decrease by \$27 million from 1988 to \$2,026 million in 1989. Increases are proposed to enhance support for long-term basic energy research, and to implement a 5 year, \$2.5 billion clean coal technology demonstration program. These increases are offset by proposed reductions in support for the energy technology programs such as fossil energy, conservation, and renewable energy where reliance is placed on the private sector to provide support for demonstrations and product development.

- **Department of Health and Human Services (HHS).**—HHS R&D activities in 1989 are estimated to be \$7.9 billion, up from \$7.2 billion in 1988. In 1989, the National Institutes of Health (NIH) will support about 20,700–21,000 research project grants and about 11,000 research trainees. In 1989, NIH obligations are estimated at \$6.2 billion.
- **National Aeronautics and Space Administration (NASA).**—NASA obligations for the conduct of R&D are estimated at about \$5.4 billion in 1989, an increase of \$637 million over 1988. This increase is necessary primarily to continue development of the Space Station and to provide for two new initiatives, the Advanced X-Ray Astrophysics Facility (AXAF) and Project Pathfinder. AXAF will expand our ability to explore x-ray features in the universe and Pathfinder will explore a variety of advanced generic technologies underlying potential future space missions that will enable expanded human presence and activity beyond Earth's orbit. For other science and applications programs, the budget continues support for major flight projects such as the Space Telescope, the Galileo mission to Jupiter, the Global Geospace Science mission and the Ocean Topography Experiment (TOPEX), and increases support for the Explorer program.
- **National Science Foundation (NSF).**—Obligations for research supported by NSF are expected to increase by about \$303 million, or about 20 percent—to \$1.8 billion in 1989. This increase is part of the Administration plan to increase investments in basic research by proposing to double the NSF budget over the next five years. The budget principally provides enhanced support for basic research across a wide spectrum of high-priority scientific and engineering disciplines,

including materials sciences, computational science and engineering, and biotechnology. Increases will also be provided for instrumentation and graduate student support. The budget also provides for new efforts in improving research and education at the undergraduate level, and the establishment of Science and Technology Centers with a one-time fully-funded appropriation of \$150 million. These new centers, modeled after the Engineering Research Centers, are intended to foster and strengthen multidisciplinary research in the basic physical and life sciences as well as to speed the transfer of such knowledge to the private sector.

- **Department of Agriculture (USDA).**—Obligations for the conduct of R&D are estimated at \$985 million for 1989, a decrease of about 3 percent from the 1988 level of \$1,018 million. Within the USDA total, the Cooperative State Research Service will provide \$255 million for research and development, primarily conducted by colleges and universities. The Agricultural Research Service expects to obligate \$529 million, an increase of \$16 million over 1988. Emphasis is given to basic research on plant and animal productivity, biotechnology, new agricultural products, water quality, food safety, protection of stratospheric ozone, and human nutrition. The Forest Service will continue its research on land management planning and forest inventory.

Table J-2 summarizes Federal support for the conduct of R&D by agency.

Table J-2. CONDUCT OF RESEARCH AND DEVELOPMENT BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1987 actual	1988 estimate	1989 estimate	1987 actual	1988 estimate	1989 estimate
Defense—Military functions.....	36,088	37,899	38,787	34,581	33,776	37,023
Health and Human Services.....	6,643	7,174	7,938	5,733	6,561	7,446
(National Institutes of Health).....	(5,850)	(6,318)	(6,229)	(4,956)	(5,643)	(6,181)
National Aeronautics and Space Administration..	3,787	4,779	5,416	3,250	3,962	4,820
Energy.....	4,724	5,071	5,165	4,682	4,941	5,082
National Science Foundation.....	1,464	1,524	1,827	1,410	1,492	1,618
Agriculture.....	946	1,018	985	921	968	961
Interior.....	403	419	396	389	420	393
Environmental Protection Agency.....	348	350	374	326	340	335
Transportation.....	322	325	317	324	352	341
Commerce.....	405	408	312	308	360	333
Veterans Administration.....	210	216	216	195	209	202
Agency for International Development.....	223	208	199	230	243	198
All other ¹	527	560	585	513	539	563
Total.....	56,089	59,952	62,517	52,862	54,162	59,314

¹ Includes the Departments of Education, Justice, Labor, Housing and Urban Development and Treasury, the Tennessee Valley Authority, the Smithsonian Institution, the Corps of Engineers, and the Nuclear Regulatory Agency.

CONDUCT OF BASIC RESEARCH

The 1989 budget continues the already strong emphasis that this Administration has placed on enhancing support for basic research across all scientific and engineering disciplines. Even in a fiscally austere environment, support for basic research, especially at universities, is an important factor in generating new knowledge to ensure continued technological innovation. It is an essential investment in the nation's future. The Federal Government has traditionally assumed a key role in support of basic research because the private sector has insufficient incentives to invest in such research. Over the course of this Administration (1981 to 1989), Federal support for basic research has increased by 52 percent in real terms.

Funding for basic research is included within the overall Federal support for the conduct of R&D. In 1989, obligations for the conduct of basic research are estimated at \$10.3 billion, an increase of \$617 million, or 6 percent above the level for 1988.

Support for basic research at universities serves the dual role of providing new knowledge and helping to ensure the future availability of high-caliber scientists and engineers. Both of these are key elements in the long-term ability of the nation to compete in global markets. University-based researchers receive about half of the total Federal obligations for basic research. Federal support for R&D at universities and colleges, more than two-thirds of which is basic research, is estimated to increase 13 percent in 1989 to a total of \$9.2 billion. This would represent a real increase of 54 percent over the period of this Administration (1981 to 1989).

Table J-3 summarizes Federal support for the conduct of basic research by agency.

R&D FACILITIES

In 1989, within the total for support for R&D facilities, funding is provided for major scientific instrumentation, including the specialized research facilities at national laboratories and university centers, e.g., particle accelerators, telescopes, and advanced computers. Such specialized facilities are critical to advancing the frontiers of science in a number of scientific disciplines. Funds for R&D facilities are also used for construction or renovation of general purpose laboratories and research support facilities.

In 1989, obligations for R&D facilities are expected to total \$2.1 billion, an increase of \$125 million from 1988. The budget provides for construction of two major new projects in DOE, the Superconducting Super Collider (SSC) accelerator facility and a 6-7 GeV synchrotron source at Argonne National Laboratory, as well as ongoing construction of a 1-2 GeV synchrotron source at Lawrence Berkeley Laboratory, an Accumulator/Booster Ring at the Brook-

Table J-3. CONDUCT OF BASIC RESEARCH BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars) ¹

Department or agency	Obligations			Outlays		
	1987 actual	1988 estimate	1989 estimate	1987 actual	1988 estimate	1989 estimate
Agencies supporting primarily physical sciences and engineering: ²						
National Science Foundation.....	1,382	1,439	1,734	1,329	1,404	1,526
National Aeronautics and Space Administration.....	1,014	1,229	1,374	865	1,017	1,223
Energy.....	1,061	1,185	1,265	1,040	1,175	1,259
Defense—Military functions.....	904	892	906	844	837	874
Interior.....	124	131	125	121	132	125
Commerce.....	26	27	27	26	25	27
Other Agencies ³	8	7	6	9	11	6
Subtotal.....	4,519	4,911	5,437	4,233	4,601	5,039
Agencies supporting primarily life and other sciences: ⁴						
Health and Human Services.....	3,859	4,160	4,260	3,282	3,767	4,204
(National Institutes of Health).....	(3,578)	(3,854)	(3,965)	(3,007)	(3,429)	(3,891)
Agriculture.....	446	471	470	430	443	450
Smithsonian Institution.....	72	77	77	70	76	73
Environmental Protection Agency.....	31	32	31	30	30	27
Veterans Administration.....	17	18	18	16	16	18
Other Agencies ⁵	19	20	12	18	19	15
Subtotal.....	4,444	4,777	4,868	3,845	4,352	4,787
Total.....	8,963	9,689	10,306	8,078	8,953	9,826

¹ Amounts reported in this table are included in totals for conduct of R&D.² Includes mathematics and computer sciences.³ Includes the Corps of Engineers, the Tennessee Valley Authority, and the Department of Transportation.⁴ Includes psychology and social sciences.⁵ Includes the Departments of Education, Labor, Justice, and Treasury, and the Agency for International Development.

haven Alternating Gradient Synchrotron, and a 3 GeV injector for the SPEAR storage ring at the Stanford Synchrotron Radiation Laboratory.

Table J-4 summarizes Federal support for R&D facilities and capital equipment.

Table J-4. RESEARCH AND DEVELOPMENT FACILITIES BY MAJOR DEPARTMENTS AND AGENCIES

(In millions of dollars)

Department or agency	Obligations			Outlays		
	1987 actual	1988 estimate	1989 estimate	1987 actual	1988 estimate	1989 estimate
Energy.....	775	939	1,132	723	918	1,026
National Aeronautics and Space Administration.....	309	429	549	314	386	479
Defense—Military functions.....	318	267	191	235	239	176
Agriculture.....	112	126	85	71	105	99
National Science Foundation.....	64	55	67	50	54	56
Health and Human Services.....	38	70	6	32	44	34
(National Institutes of Health).....	(36)	(68)	(5)	(29)	(39)	(33)
All other ¹	63	75	56	39	65	57
Total.....	1,680	1,961	2,086	1,464	1,810	1,926

¹ Includes the Departments of Transportation, Commerce, Education, Interior, Justice, and Treasury, Veterans Administration, Tennessee Valley Authority, Agency for International Development, and the Smithsonian Institution.

ARCTIC RESEARCH

Two complementary policy documents currently govern U.S. Arctic research policy. The Arctic Research and Policy Act of 1984 (Public Law 98-373) requires an “. . . integrated, coherent, and multiagency request . . .” for research in the Arctic as part of the President’s annual budget request to Congress. National Security Decision Directive 90 (NSDD 90, April 14, 1983) identifies four basic elements of U.S. Arctic Policy:

- protection of essential security interests in the Arctic region, including the adjacent seas and airspace;
- support for sound, rational development in the Arctic region, while minimizing adverse effects on the environment;
- promotion of scientific research in fields which contribute knowledge about the Arctic, or which are most advantageously studied in the Arctic; and
- promotion of mutually beneficial international cooperation in the Arctic to achieve the above objectives.

In response to these directives, the Interagency Arctic Research Policy Committee (established by Public Law 98-373) has compiled a detailed listing of agency programs in Arctic research, including budgetary estimates, and has grouped them into three major categories of national concern: national security, rational development, and the Arctic as a natural laboratory.

Based on current activities and future needs, the Interagency Committee, in consultation with the Arctic Research Commission, the Governor of the State of Alaska, the residents of the Arctic, the private sector, and public interest groups, prepared a comprehensive plan for the overall Federal effort in Arctic research.

This U.S. Arctic Research Plan was transmitted to the President on June 23, 1987. The President sent the Plan to Congress on July 31, 1987.

Table J-5 provides a summary of Federal support for Arctic research integrated by major category. These estimates are subsumed within agency totals for the conduct of research and development.

Table J-5. FEDERAL SUPPORT FOR ARCTIC RESEARCH ¹

(Obligations in thousands of dollars)

Category	1987 actual	1988 estimate	1989 estimate
National security	22,197	23,647	25,129
Rational development	30,535	29,250	29,525
Natural laboratory	38,362	41,464	40,626
Total	91,094	94,361	95,280

¹ Includes the Departments of Defense, Energy, Health and Human Services, Interior, Commerce, Agriculture, and Transportation, the National Science Foundation, the National Aeronautics and Space Administration, the Environmental Protection Agency, and the Smithsonian Institution.

PART II. AGENCY R&D PROGRAMS

Presented below are summaries of the R&D activities of the 12 agencies whose R&D obligations individually exceed \$150 million.

DEPARTMENT OF DEFENSE

Research and development in the Department of Defense ranges from support of basic research to full scale development of hardware and its testing and evaluation. The primary purpose of DOD R&D is to provide new strategic and tactical weapons and supporting systems to improve the Nation's defense. R&D efforts directly support the deployment of technologically superior systems to offset quantitative advantages of potential adversaries. Obligations for DOD research and development, including R&D facilities, total \$39.0 billion, about 60 percent of total Federal funding for research and development, including R&D facilities, in 1989.

In 1989, DOD obligations for the conduct of R&D will increase by \$888 million, or 2 percent above the 1988 level, to \$38.8 billion. DOD funding of technology base programs (basic and applied research) will increase from about \$3.1 billion in 1988 to about \$3.3 billion in 1989. Increases for advanced technology development of \$854 million primarily reflect increases for the Strategic Defense Initiative. Funding for R&D facilities will decrease by \$76 million from 1988 to a total of \$191 million in 1989.

By mission category, major R&D efforts for 1989 include:

—*Technology Base and Advanced Technology Development.*— These programs constitute the research end of the spectrum of programs that comprise Research and Development, Test and Evaluation. They are intended to provide choices for future system development and to help avoid technological surprise.

Two of the areas emphasized are materials research and electronics, including the Very High Speed Integrated Circuits program and Millimeter Wave Monolithic Integrated Circuits program. The private sector, with some DOD funding support, has formed a consortium, SEMATECH, to maintain world-class semiconductor manufacturing capability in this country. Funding in this area also supports the joint DOD/NASA National Aerospace Plane.

The Strategic Defense Initiative, a program to investigate the feasibility of defense against ballistic missiles, will increase to \$4.6 billion in 1989.

—*Strategic Programs.*— Major programs for 1989 include the air-launched short-range attack missile, the B-2 Advanced Technology Bomber, the Advanced Cruise Missile, and the MILSTAR communi-

cations satellite. The Trident II submarine-launched ballistic missile and the Peacekeeper missile development programs are near completion. The budget also contains funds for ICBM modernization, including development of the Small ICBM and the rail garrison basing mode for the Peacekeeper. Requested funding for the Small ICBM has been reduced substantially from the 1988 level, pending further review of this program.

—*Tactical Programs.*—These programs support the development of systems to increase the capability of U.S. general purpose and theater nuclear forces, and to improve the capability to project forces rapidly anywhere in the world where the vital interests of the United States are threatened. In 1989 these programs include:

- in the Army, continued development of advanced anti-tank weapon systems, cannon-fired precision munitions, and ground-based missiles and control systems to fulfill its air defense mission.
- in the Navy, a major effort to improve air, surface and submarine-based anti-submarine warfare capabilities, including development of the Seawolf attack submarine. Other key programs include the V-22 Osprey tilt-rotor aircraft, the Advanced Tactical Aircraft, and continuation of upgrades to the F-14 fighter. Several efforts are being continued to improve fleet air defenses.
- in the Air Force, continued development of the Joint STARS radar, the Advanced Tactical Fighter the C-17 transport aircraft, and various electronic warfare programs. Work on munitions for use against hardened targets, development of TR-1 surveillance aircraft sensors and ground stations, and AWACS radar system improvements also continue.

—*Intelligence and Communications, Program Management and Support.*—R&D supported by these programs is directed toward improvements in defense intelligence systems, command control and communications programs, and test and evaluation capabilities. Work will continue in such areas as the use of technology to reduce manufacturing costs and to extend the life and capability of existing defense systems.

Table J-6 provides the details of the Department of Defense military R&D funding.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA invests in R&D programs to provide for a permanent U.S. presence in space with a manned Space Station; to support the Shuttle-based Space Transportation System; to advance knowledge of the Earth, the near-earth environment, the solar system and the universe; and to support long-term research and technology ad-

Table J-6. DEPARTMENT OF DEFENSE—MILITARY RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity	1987 actual	1988 estimate	1989 estimate
OBLIGATIONS			
Conduct of R&D:			
Research, development, test and evaluation:			
Technology base.....	2,817	3,141	3,311
Advanced technology development.....	4,855	5,534	6,389
Strategic programs.....	7,817	7,162	6,605
Tactical programs.....	10,761	12,509	13,008
Intelligence and communications.....	4,802	4,797	4,499
Program management and support.....	3,825	3,866	4,068
Other appropriations.....	1,211	889	908
Total conduct of R&D ¹	36,088	37,899	38,787
Total conduct of basic research, included above.....	(904)	(892)	(906)
R&D facilities.....	318	267	191
Total obligations.....	36,406	38,167	38,978
OUTLAYS			
Conduct of R&D.....	34,581	33,776	37,023
R&D facilities.....	235	239	176
Total outlays.....	34,816	34,016	37,199

¹ Includes funds for Operational Systems Development of \$9,875 million in 1987, \$9,370 million in 1988 and \$9,493 million in 1989.

vancement. It also supports long-term research and selected systems technology projects in aeronautics.

R&D accounts for over 50 percent of the total budget for NASA. The balance of the NASA budget includes funding primarily for Shuttle production and operations, tracking and data acquisition activities, and related institutional support.

In 1989, NASA obligations for R&D including facilities for the agency will be approximately \$6.0 billion, a net increase of \$757 million, or 15 percent, over 1988. Within this total, funds are available to complete projects currently under development, to augment major research and technology programs, and to initiate a major new project in space science and applications. Within the total funding for R&D, basic research obligations in 1989 are estimated at \$1.4 billion, an increase of \$146 million or 12 percent over 1988.

Space Station.—Obligations for Space Station R&D are estimated to increase from \$415 million in 1988 to nearly \$739 million in 1989. This increase is consistent with funding needed to pursue design, definition, and development of the space station for planned initial operating capability in the mid-1990's. In addition, the budget will propose a 3-year appropriation for the Space Station in order to provide necessary program and funding stability, and later

in the year, legislation to establish a total program cost ceiling to ensure strong cost control discipline.

The Space Station is intended to enhance the nation's science and applications programs, to help develop advanced technologies potentially useful to the economy, and to encourage greater commercial use of space.

Space transportation systems capability.—Obligations for space transportation systems capability are estimated in 1989 at \$600 million, a slight decrease from 1988. The 1989 budget provides for sustained research support for the Space Shuttle program to achieve routine and reliable access to space for all planned users, and for continued research investments to further improve the safety and reliability of the Shuttle fleet. Other major continuing activities will include planning for the use of Spacelab; further development of the tethered satellite program, a Shuttle-based science program conducted in cooperation with the Italian government; and development of an Orbital Maneuvering Vehicle for maneuvering spacecraft and payloads in near-Earth orbit.

Space science and applications.—Obligations for space science and applications are estimated in 1989 at \$1.8 billion, an increase of \$39 million over the 1988 level. The funding provided will allow initiation of a major new flight project, continued support of ongoing flight projects, and the analysis of scientific data being sent back to Earth from spacecraft now in space.

The 1989 budget continues support for space science research to enhance understanding of the Sun, the planets, and the universe; space-related research on the Earth's climate, resources, surface and atmosphere; research to advance knowledge in materials science and materials processing through low gravity experiments in space; and continuing long-term basic technology work for satellite communications.

For 1989, new proposals include:

- a major new science project proposed for initiation in 1989 is the Advanced X-ray Astrophysics Facility (AXAF). The AXAF mission will provide a space-based telescope for viewing in the X-ray portion of the spectrum, 1,000 times more capable than any previous or planned x-ray mission;
- augmentations for the Explorer program and for small payloads launched by SCOUT expendable launch vehicles;
- payloads will be developed for flight on promising commercial space facilities; and
- augmentations to the Microwave Observing program (formerly the Search for Extraterrestrial Intelligence activity) for the development of technologies necessary to analyze microwave signals from space for evidence of advanced life elsewhere in the galaxy.

Continuing development efforts for ongoing major flight projects yet to be launched include:

- the Hubble Space Telescope, planned for launch in 1989, which is expected to serve as a major astronomy facility for a 10 to 15 year period;
- the Gamma Ray Observatory, planned for launch in 1990, which will enhance basic research in high energy astrophysics, providing new knowledge about the origin of the universe;
- Spacelab astronomy experiments, which will be conducted on the Shuttle with the goal of improving our understanding of the Earth's vicinity, the Sun and the universe;
- the Magellan project, planned for launch in 1989, to map the planet Venus;
- the Mars Observer Mission, a major space science project planned for launch in 1992, to continue the scientific exploration of the planet Mars;
- the Galileo orbiter and probe mission to Jupiter, now planned for launch in 1989, to carry out long-term studies of the planet, its satellites, and its magnetosphere;
- the Upper Atmosphere Research Satellite (UARS) spacecraft, to be launched in 1991, to investigate the chemical composition of the Earth's stratosphere and mesosphere;
- the Scatterometer project, a research instrument to measure global wind patterns on the surface of the oceans. This instrument will be flown in 1992; and
- the Ocean Topography Experiment (TOPEX) scheduled for a 1991 launch as part of a cooperative mission with France.

Continued support will be provided in 1988 for several spacecraft already in flight including:

- two Voyager spacecraft, launched in 1977, which have successfully encountered Jupiter and Saturn; Voyager 2 encountered Uranus in January 1986 and is scheduled to fly by Neptune in 1989; and
- a number of smaller, Explorer-class scientific satellites launched in prior years;

The budget also provides for continuing research and technology work in areas such as space-related life science research; near-Earth experiments using balloons and sounding rockets; research in geodynamics, ocean processes, and atmospheric dynamics; Shuttle-based science and applications experiments; and preparations for the future launch of planned missions. Continuing efforts to improve satellite communications technology will be refocused towards generic and longer-term technology-based efforts, in recognition of the responsibility of the private sector to pursue relatively near-term satellite communications technologies.

Commercial Programs.—The goal of these programs is to support opportunities for expansion of U.S. private sector investment and involvement in civil space activities. These programs include the Technology Utilization program which promotes the dissemination of new developments in aerospace technology to non-aerospace industrial sectors, and the Commercial Use of Space program which encourages increased private sector awareness, participation and investment in space technologies. Support will continue for the 16 centers for the Commercial Development of Space which have been established in a wide range of disciplines including materials processing, robotics, and remote sensing. These centers were designed to create close working relationships between the private sector, the States, and academia to encourage investments in and use of space technology.

Transatmospheric research and technology.—In 1989, funding will increase as planned to continue research and advanced technology in the National Aerospace Plane (NASP) program leading to a transatmospheric flight research vehicle demonstration in the 1990's. The NASP program is jointly supported with DOD.

Aeronautical research and technology.—Obligations for aeronautical research and technology are estimated to increase from \$289 million to \$349 million in the 1989 budget. Research in fundamental aeronautical disciplines such as advanced materials and structures, and advanced propulsion will be augmented in recognition of the key role that these technologies play in ensuring the ability of the U.S. to remain competitive in international markets.

Space research and technology.—Obligations for space research and technology are estimated to increase from \$277 million to \$374 million in the 1989 budget. The 1989 budget continues the Civil Space Technology Initiative (CSTI) as planned and also proposes \$100 million to begin a new program within space research and technology, Project Pathfinder. This effort will support research in a wide variety of technology areas including automated rendezvous and docking, orbital transfer propulsion, optical communications and closed loop life support systems. Such technologies will be key to achieving the national long-range goal of expanding human presence and activity beyond the Earth's orbit into the Solar System. Pathfinder will involve researchers from all sectors, industry, universities and the Federal government.

Agency-wide support activities.—Obligations for agency-wide support activities will total \$1.4 billion in 1989, a 10 percent increase above the 1988 level. These programs include primarily R&D-related NASA civil service and administrative costs; tracking and data acquisition system improvements; and safety, reliability and quality assurance.

Table J-7 provides the details of NASA's R&D funding.

Table J-7. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity	1987 actual	1988 estimate	1989 estimate
OBLIGATIONS			
Conduct of R&D:			
Space station.....	266	415	739
Space transportation systems capability.....	427	611	600
Space science and applications.....	1,497	1,793	1,832
Commercial programs.....	32	88	59
Transatmospheric research and technology.....	43	52	83
Aeronautical research and technology.....	324	289	349
Space research and technology.....	161	277	374
Agency-wide support activities:			
Safety, reliability and quality assurance.....	11	17	22
Tracking and data acquisition.....	18	18	19
Research and program management.....	1,009	1,218	1,340
Total conduct of R&D.....	3,787	4,779	5,416
Total conduct of basic research, included above.....	(1,014)	(1,229)	(1,374)
R&D facilities.....	309	429	549
Total obligations.....	4,096	5,209	5,965
OUTLAYS			
Conduct of R&D.....	3,250	3,962	4,820
R&D facilities.....	314	386	479
Total outlays.....	3,564	4,348	5,299

DEPARTMENT OF ENERGY

The R&D programs of the Department of Energy include: a *National Defense Program* related to the development and testing of nuclear weapons; a *General Science Program* of basic research in high energy physics and nuclear sciences; and an *Energy Program* focused on longer-term R&D in support of energy technology development. Table J-8 provides summary information on the funding of these programs.

Obligations for the conduct of R&D by the Department are estimated to total \$5.2 billion in 1989, an increase of \$95 million over 1988. Obligations in 1989 for R&D facilities, including the construction or upgrading of general purpose laboratories and other research support facilities, will amount to \$1.1 billion, an increase of \$193 million over 1988.

Obligations for the conduct of basic research, included in the total for the conduct of R&D, are estimated to be \$1,265 million in 1989, an increase of \$80 million over 1988. Within the basic research total, funds are provided to continue or initiate a number of major projects in both the energy program and the general science program that will enhance the nation's capability in basic research

at the frontiers of science and thus help contribute to U.S. global competitiveness.

The *National Defense Program* supports the continued research, development and testing of nuclear weapons. It also supports the development of improved naval propulsion reactors, technologies for monitoring nuclear weapons treaties, and methods for safeguarding nuclear materials. In addition, R&D efforts will continue in developing methods for the safe storage and disposal of radioactive wastes resulting from weapons production. Obligations for the conduct of R&D by the national defense program will be \$2.4 billion in 1989, a level comparable to the 1988 level. Funding for conduct of R&D supports ongoing Department of Defense work including isotope separation techniques, weapons testing, and research in the basic physics of nuclear weapons. R&D in support of the Strategic Defense Initiative (SDI) will continue to focus on investigations of Nuclear Directed Energy Weapons (NDEW) to assess the Soviet NDEW capability to threaten a strategic defense system. SDI funding will be maintained at level of effort at \$285 million in 1989.

The *General Science Program* supports basic research in high energy and nuclear physics. A proposed increase of \$79 million, to \$704 million in 1989, for the conduct of basic research will enhance support for theoretical and experimental efforts to understand the basic constituents of matter and energy and the forces that govern their interaction. Obligations for R&D facilities will also increase \$313 million to \$490 million in 1989, mainly for the initiation of construction of the Superconducting Super Collider (SSC) accelerator facility. The SSC is the largest and most powerful high energy physics facility ever proposed for construction. It will be a 53 mile circumference proton-proton collider producing particle collisions with total energies approaching 40 trillion electron volts, an energy twenty times the highest energy available in the world today. In 1989, the R&D program for the SSC will also be significantly enhanced. The major new thrust in this research will be the initiation of fabrication of pre-production full-scale superconducting magnets by American industry. Industrial participation is especially crucial for this aspect of the project since the heart of the SSC is the collider which consists of two rings of superconducting magnets requiring some 8,000 dipoles and nearly 1,800 quadrupole magnets.

The 1989 budget request will also provide for:

- increased utilization of existing accelerator facilities, with major increases in levels of operation of the Stanford Linear Collider and of the recently upgraded PEP electron-positron collider at SLAC; the Alternating Gradient Synchrotron complex at Brookhaven National Laboratory and Tevatron I and II at Fermilab;

- continued construction of the Central Computing Facility project at Fermilab, the Accumulator/Booster Ring upgrade at the Brookhaven Alternating Gradient Synchrotron and the advanced nuclear physics electron accelerator facility (CEBAF) at Newport News, Virginia; and
- continued support for advanced accelerator and detector research and development activities related to effective utilization and novel exploitation of existing and next-generation high energy and nuclear physics accelerators.

The *Energy Program* funds basic science and engineering research underlying both nuclear and non-nuclear technologies, R&D to support development of specific energy technologies, and research on the environmental and human health effects of energy production technologies. Energy program obligations for the conduct of R&D will decrease by \$27 million from the 1988 level to \$2,026 million in 1989. This decrease consists of increases for basic supporting research and the clean coal technology program, offset by proposed reductions in support for nearer-term non-nuclear energy technology programs. Obligations for R&D facilities in this program will be \$215 million, a decrease of \$104 million from 1988. This decrease consists almost entirely of the elimination of Congressional University Building add-ons for 1988.

The *basic energy sciences* programs will continue to support the conduct of research in the fields of nuclear science, chemistry, engineering, materials science, applied mathematics, biology, and the geosciences. The program will continue to provide the fundamental scientific and technical base for future advances in both nuclear and non-nuclear technology development.

Funding for basic energy sciences activities is proposed at a level of \$516 million, an increase of \$37 million for the core research and the user facilities programs. Support for the conduct of research will increase nearly \$23 million, or 6 percent over the 1988 level. Increased funding is proposed to enhance the Department's high temperature superconducting materials research effort while still maintaining level of effort in other high priority advanced materials research such as ceramics, polymers, and semiconductors. Funds in 1989 are also proposed for an additional Class VII computer to handle the backlog of computational needs of all the basic research programs of DOE and for R&D activities related to advanced synchrotron and neutron facilities required for future state-of-the-art engineering and science research.

The 1989 budget also continues to provide support for construction of the 1-2 GeV synchrotron at Lawrence Berkeley Laboratory, the experimental detection halls at the Los Alamos Neutron Scattering Center and the 3 GeV injector for the SPEAR Storage Ring at the Stanford Synchrotron Radiation Laboratory. In addi-

tion, funds are proposed to initiate the construction of a 6-7 GeV synchrotron source at the Argonne National Laboratory.

In 1989 a new account will be created to support the operation and construction of the basic research user facilities formerly funded under the basic energy sciences program and the general science programs. These major national facilities, used by researchers from industry, universities and national laboratories, include the National Synchrotron Light Source (NSLS) at the Brookhaven National Laboratory, the Intense Pulsed Neutron Source (IPNS) facility at Argonne National Laboratory, and the Combustion Research Facility at Sandia National Laboratory as well as Fermilab, SLAC, LAMPF, and the Brookhaven high energy and nuclear physics accelerator facilities. Both the 6-7 GeV synchrotron source and the SSC will also be supported by this new account. Funds to maintain operations of all existing research facilities at the 1988 level are also included in the 1989 basic research user facility budget.

In 1988 the *Energy Program* was expanded to include the *clean coal technology* demonstration program. The goal of this program is to provide support for projects to demonstrate technologies that will burn coal more cleanly. The Department solicits proposals from the private sector for at least 50 percent cost-shared, full-scale demonstrations of clean coal technologies. Typical examples of such technologies include: advanced coal cleaning techniques, alternate combustion technologies, preparation of clean coal-based fuels, and post-combustion cleanup systems. The proposed 1989 budget requests advance appropriations to provide full funding for the government's share of a five-year, \$2.5 billion clean coal technology program. Congress, to date, has provided the program \$200 million for 1988 and \$525 million for 1989. The current request seeks additional advance appropriations totaling \$1,775 million, including \$575 million for 1990, \$600 million for 1991, and \$600 million for 1992. These funds will then be available to implement the demonstration program consistent with the recommendations made in the Report of the U.S. and Canadian Special Envoys on Acid Rain, that both the President and the Canadian Prime Minister have endorsed.

The 1989 budget will continue the redirection of the on-going non-nuclear R&D programs to limit federal support for nearer-term technology development. To increase the involvement of the private sector in the direction and management of industry-based R&D programs and to leverage scarce Federal funds, \$14 million will, however, be available in 1989 to support DOE participation in industry-cooperative R&D ventures in broad areas of generic technology development. Obligations for the conduct of R&D in the technology base programs of the *fossil, solar/renewables* and *con-*

ervation programs are expected to be \$379 million in 1989, a decrease of about \$251 million from 1988.

Funding proposed for the conduct of fossil related R&D and associated facilities will be \$168 million in 1989, a decrease of \$159 million from 1988. The 1989 request continues to support high priority research in coal chemistry and use, environmental controls, coal conversion to liquid and gaseous fuels, and better extraction methods for petroleum and natural gas. In addition to an enhanced geosciences program, a program to support industry formed cooperative R&D ventures at a level of \$9 million is also proposed.

Research in support of *solar and other renewable energy* technologies, proposed at a level of \$125 million, will emphasize longer term, technology base R&D in areas such as photovoltaics, solar thermal energy, biofuels, wind and geothermal energy, electrical energy systems, and energy storage. In 1989, the electrical energy transmission and storage systems research budget includes a \$13 million initiative to study potential electrical utility applications of the new high temperature superconducting materials and also an industry-cooperative R&D venture program to provide support for industry driven applied R&D.

The total request in 1989 for the *energy conservation* R&D program is \$86 million and includes research in buildings and community systems, industry, and transportation. In 1989, support will continue for the recently completed materials engineering user facility at Oak Ridge National Laboratory (the High Temperature Materials Laboratory) and for the advanced materials research that is a major focus of the core research program in energy conservation. The proposed 1989 budget also proposes a new materials research initiative to explore end-use applications of the new high temperature superconductors.

The 1989 budget continues to provide for a broad program of research in nuclear *fission* and *fusion* energy technologies. Total obligations for these R&D programs will be about \$715 million in 1989, an increase of \$33 million over the 1988 level. In the *fission* program, obligations of \$241 million are estimated for the conduct of R&D in 1989, approximately the same as in 1988. Total obligations for R&D facilities in 1989 will be \$111 million. The nuclear fission R&D program will continue to focus major effort on the advanced civilian reactor program and R&D on reactor concepts that can meet space and military nuclear power requirements. The program will continue to serve national security interests as well as maintain a technical and industrial base for any future deployment of advanced nuclear technologies in the commercial sector.

In the *magnetic fusion* program, funding of \$360 million is proposed for the conduct of R&D, an increase of \$25 million over 1988.

In 1989, the fusion program will focus on the development of the toroidal magnetic confinement system by supporting the continued operation of Princeton's large tokamak test reactor (TFTR), of GA Technologies' Doublet-III-D machine, of the Oak Ridge National Laboratory's ATF torsatron, and of the free electron laser heating experiment (MTX) at Livermore National Laboratory. Fabrication of three smaller toroidal devices also will continue in 1989: a reversed field pinch machine (RFP) at Los Alamos, a compact toroid called a field reversed configuration (FRC) experiment, and a high field high density tokamak (Alcator C-MOD) at Massachusetts Institute of Technology (MIT). Funds are also provided to continue the R&D and design effort for a Compact Ignition Tokamak (CIT), a machine that will prove a plasma can ignite and burn in a predictable and controllable way. Other research that supports the President's Geneva Initiative on expanded cooperation with the Soviets in fusion research will also continue in 1989.

Finally, the *energy program* supports R&D to better understand the *biological* and *environmental* effects of energy production and use. The level of funding for the biological and environmental research program will be \$249 million in 1989, providing a 10 percent increase for the core research program. The biological program emphasizes the health effects of radiation, the use of radiation in medical diagnosis and therapy, and generic biological research related to radiation and other cellular traumas. In 1989 support for the human genome project initiated in 1988 will continue to increase. The new tools and methodologies to be developed by the research effort are expected to markedly increase the pace and lower the cost for mapping and sequencing human DNA. Results from the research hold the promise for enabling the structure and function of genes to be decoded and for detecting changes in human DNA caused by exposure to toxic pollutants.

The environmental program supports research in areas related to energy technologies, such as atmospheric processes involved in acid rain formation and deposition and carbon dioxide-induced climatic effects. A major new thrust in 1989 will be an expanded program of research to develop new noninvasive tools and methods for detecting and decontaminating subsurface toxic wastes. Research into the health effects of radon and a survey of factors affecting possible methods of mitigating radon levels in indoor environments will also continue in 1989. Proposed funding in 1989 for radon-related, acid rain-related, and carbon dioxide-related research is over \$38 million, nearly 12 percent higher than 1988.

Table J-8 provides the details of funding for the Department of Energy.

Table J-8. DEPARTMENT OF ENERGY

(In millions of dollars)

Type of activity	1987 actual	1988 estimate	1989 estimate
OBLIGATIONS			
Conduct of R&D:			
National defense program.....	2,358	2,393	2,435
General science program.....	569	625	704
Energy program.....	1,797	2,053	2,026
Total conduct of R&D.....	4,724	5,071	5,165
Total conduct of basic research, included above.....	(1,061)	(1,185)	(1,265)
R&D facilities.....	775	939	1,132
Total obligations.....	5,499	6,010	6,297
OUTLAYS			
Conduct of R&D.....	4,682	4,941	5,082
R&D facilities.....	723	918	1,026
Total outlays.....	5,405	5,859	6,108

DEPARTMENT OF HEALTH AND HUMAN SERVICES

The Department of Health and Human Services is expected to obligate a total of \$7.9 billion in 1989 for the conduct of R&D. Within this total, funding for basic research is estimated to be \$4.3 billion. Direct obligations for R&D facilities will total \$6.3 million in 1989, with Federal overhead payments providing additional funds which can be used to replace or modernize existing R&D facilities.

Health.—About 80 percent of the Department's funds for the conduct of R&D will be obligated by the National Institutes of Health (excluding AIDS R&D) for biomedical research to advance the nation's capabilities for the prevention, diagnosis, and treatment of disease. Several other agencies within the Department—the Alcohol, Drug Abuse, and Mental Health Administration, the Food and Drug Administration, the Centers for Disease Control, the Health Resources and Services Administration, the Health Care Financing Administration, and the Office of the Assistant Secretary for Health—also support health-related research.

The *National Institutes of Health (NIH)* consists of 12 separate institutes which will obligate \$6.2 billion (excluding AIDS R&D) in 1989 for the conduct of R&D, a 5 percent increase over the comparable 1988 level. (All Public Health Service AIDS funds will be requested under a single account in 1989.) NIH will fund about 20,600–21,000 research project grants and about 11,000–11,100 research trainees. Continued emphasis will be given to support of basic research in 1989. About 64 percent, or \$4.0 billion, of NIH's proposed R&D budget will support basic research.

Among the continuing R&D activities to be supported by NIH are:

- continuation of research and cooperative clinical trials on the Acquired Immune Deficiency Syndrome (AIDS); and
- clinical research with emphasis on medical intervention in the disease process, including prototype development and refinement of products, techniques, processes, methods, and practices.

The *Alcohol, Drug Abuse and Mental Health Administration (ADAMHA)* conducts studies on the causes, prevention and treatment of alcohol and drug abuse and on mental disease and neurological disorders, with emphasis on improving knowledge of effective prevention of these public health problems.

The 1989 budget continues to emphasize research into drug abuse, and stabilizes ADAMHA's extramural research programs in biomedical, behavioral and clinical areas by supporting between 1,650 and 1,825 research project grants per year. ADAMHA will obligate a total of \$522 million in 1989 for R&D.

The *Food and Drug Administration* supports research relevant to its mission of regulating food, drugs, biologics, medical devices and radiological products. In 1989, obligations for these activities are estimated at \$88 million.

The *Centers for Disease Control* support studies on the epidemiology and control of communicable diseases and on health promotion and disease prevention. In 1989, obligations for these activities are estimated at \$63 million.

Other Health Related Agencies within the Department support research in areas such as the efficacy and cost-effectiveness of emerging health care technologies; the effect of increased numbers of physicians on access to care and health care costs; and, survey methods and techniques for analysis of health statistics. This support is provided through programs of the Health Resources and Services Administration, the Office of the Assistant Secretary for Health and the Health Care Financing Administration.

In 1989, the Administration is proposing the Health Care Improvement Fund, to be administered through the Health Resources and Services Administration. The Fund would be dedicated to selectively supporting assessments of medical technologies and medical practices with the potential to reduce costs without impairing quality of care. The Administration proposes \$15 million for this activity in 1989.

Human services.—Most of the 1989 funding for HHS' human services R&D activities is included in the \$77 million requested for Human Services Research, Training, and Demonstrations under the Office of Human Development Services (OHDS). OHDS will support a variety of development and social services research on

the Head Start program, the elderly, child abuse and neglect, and family and community support systems.

Table J-9 provides details of the R&D funding of the Department of Health and Human Services.

Table J-9. DEPARTMENT OF HEALTH AND HUMAN SERVICES—RESEARCH AND DEVELOPMENT

(In millions of dollars)

Type of activity and organizational units	1987 actual	1988 estimate	1989 estimate
OBLIGATIONS			
Conduct of R&D:			
Health:			
National Institutes of Health.....	5,850	6,318	6,229
Acquired Immune Deficiency Syndrome (AIDS) ¹			900
Alcohol, Drug Abuse, and Mental Health Administration.....	506	561	522
Food and Drug Administration.....	85	91	88
Centers for Disease Control.....	65	72	63
Health Care Financing Administration.....	28	27	32
Office of the Assistant Secretary for Health.....	24	23	23
Health Resources and Services Administration.....	10	11	11
Subtotal, Health.....	6,568	7,103	7,868
Human Services:			
Office of Human Development Services.....	50	51	51
Social Security Administration.....	14	12	10
Family Support Administration.....	3	3	3
Departmental Management.....	8	5	5
Subtotal, Human Services.....	75	71	70
Total conduct of R&D.....	6,643	7,174	7,938
Total conduct of basic research, included above.....	(3,859)	(4,160)	(4,260)
R&D facilities.....	38	70	6
Total obligations.....	6,680	7,244	7,944
OUTLAYS			
Conduct of R&D.....	5,733	6,561	7,446
R&D facilities.....	32	44	34
Total outlays.....	5,765	6,605	7,480

¹ All Public Health Service AIDS funds will be requested under a single account in 1989.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) supports primarily basic research in all disciplines through grants to scientists and engineers in academic institutions. NSF support is particularly important because it complements the R&D programs of other agencies and assists in balancing Federal support for promising research across all fields of science and engineering.

The 1989 NSF budget provides \$1.8 billion in obligations for the conduct of R&D, an increase of \$303 million or about 20 percent above 1988. Within this total, support for basic research will also increase by about 20 percent. This increase is part of the Adminis-

trations plan to increase investments in basic research by proposing to double the NSF budget over the next five years.

For 1989, emphasis will be placed on three major themes:

- *Education and Human Resources* (\$285 million, a 18 percent increase over 1988): will provide increased support for the NSF Graduate Fellowship Program 100 additional Fellows, for a total of about 860 new awards and for the Presidential Young Investigators program 200 new awards, for a total of about 800 new awards. An increase for undergraduate programs will provide opportunities for faculty enhancement, and student research participation as well as providing for much needed instrumentation. There will also be an enhancement of support to encourage the participation of underrepresented groups in scientific and engineering research.
- *Basic Science and Technology Centers and Groups* (\$473 million, a 61 percent increase over 1988): will provide increases for ongoing efforts such as the Engineering Research Centers (ERCs), the Materials Research Laboratories, and the inter-agency Plant Science Centers, as well as the establishment of Science and Technology Centers, with a one-time \$150 million appropriation in 1989. This program will expand the concept of the ERCs to fields of science such as biology, materials science, and computer and information sciences. Like the ERCs, these centers will be university-based, multidisciplinary, will incorporate strong involvement by the private sector and state and local governments, and will provide important opportunities to train future scientists and engineers. It is expected that perhaps as many as 15 such centers will be funded over the next five years. In addition to the centers, a number of research areas, including global geosciences, mathematics, materials research and biotechnology, will be the focus for research by a number of coordinated groups.
- *Strengthened Disciplinary Programs and Facilities* (\$1.2 billion, an increase of 9 percent over 1988): will provide for a continued steady improvement of NSF's traditional broad support for high-quality research programs and specialized research facilities across a wide spectrum of disciplines. A high priority will be given to increasing grant sizes and enhancement of support for emerging fields of high scientific opportunity (e.g., materials chemistry, cosmology, manufacturing processes). In addition, specialized research facilities including the Very Long Baseline Array radio-telescope, Advanced Scientific Computing Centers and supercomputer networks will receive priority attention. Continuing support for the National Center for Atmospheric Research and the National Astronomy Centers is provided. Three physics facility upgrades will

be completed and become operational in FY 1989; the Cornell Electron Storage Ring, the Indiana University Cyclotron Facility, and the Michigan State University National Superconducting Cyclotron Laboratory. The FY 1989 budget also provides funds for the U.S. Antarctic Program (USAP) to lease a new icebreaker to support research as well as operations in the Antarctic. These funds include significant upgrades of research laboratory facilities at the McMurdo Station and the refurbishment of a LC-130 research aircraft. The USAP is managed by NSF and is the principal expression of U.S. presence on the Antarctic continent.

DEPARTMENT OF AGRICULTURE

The Department of Agriculture supports research and development in several disciplines related to agriculture and forestry to ensure the continued high productivity of U.S. agricultural and forest lands.

Obligations of the Department for the conduct of research and development are expected to total \$985 million in 1989, compared to the \$1,018 million in 1988. Of the total, \$470 million will support basic agricultural research, maintaining the 1988 estimated level. The Department's 1989 Budget for research and development is highlighted below by major bureau.

The *Agricultural Research Service* expects to obligate \$529 million in 1989 to conduct basic and applied research in plant and animal productivity; water quality; food safety; protection of stratospheric ozone; human nutrition; and new agricultural products. This is a 3 percent increase over the 1988 level. In 1989, increased emphasis will be placed on basic research in plant germplasm and biotechnology to improve the profitability and competitiveness of U.S. agriculture. Research will also be directed at reducing fat in consumer meats.

The *Cooperative State Research Service (CSRS)* estimates that \$255 million will be obligated in 1989. CSRS supports research on agriculture and forestry through grants to land-grant colleges. Also, within CSRS, the Competitive Research Grants program funds basic research in biotechnology, plant and animal science, pest science, and human nutrition.

The *Forest Service* estimates that \$129 million will be obligated for research and development in 1989. This represents a decrease from the \$136 million obligation estimate in 1988. The long-range goal of forestry research is to provide the information needed to manage and protect forest and range land resources, and to gain maximum economic and social benefits from their use.

Other Departmental programs will obligate approximately \$71 million for R&D in 1989, covering a broad spectrum of research

activities, such as research in agricultural economics, international agricultural cooperation, and statistical reporting.

DEPARTMENT OF COMMERCE

The Department of Commerce undertakes research primarily in ocean science and engineering, meteorology and weather forecasting, and in the maintenance of measurement standards to support science and industry.

Obligations for the conduct of R&D by the Department in 1989 are estimated at \$312 million, a decrease of \$96 million from 1988. This reflects reduced levels of support by the National Oceanic and Atmospheric Administration for applied research, that is more appropriately the responsibility of state and local governments or the private sector.

National Oceanic and Atmospheric Administration (NOAA).—NOAA obligations for the conduct of research and development will decrease from \$282 million in 1988 to \$180 million in 1989 as a result of greater reliance on support from the private sector and state and local governments, and elimination of lower priority research in such programs as Seafloor Spreading Center Research, National Undersea Research Program, National Sea Grant College Program, and some programs of the National Marine Fisheries Service. Funding of \$15 million is proposed for an integrated program in Earth System Science that will provide a new coordinated approach to conducting research to improve predictions of global climate change. Acid rain research and R&D to support the Pacific Salmon Treaty will be maintained.

National Bureau of Standards (NBS).—NBS conducts research aimed at maintaining and improving a system of measurement required to support the nation's industrial and scientific endeavors. In 1989, NBS is expected to obligate \$120 million for the conduct of R&D. This represents an increase of \$10 million from the 1988 estimated level. Funding increases will support development of measurements and standards for superconductors, process and quality control, high-performance composites, fiber optics, and bioprocess engineering. Funding for fire and building research will be reduced because such research can and should appropriately be supported by other sectors of the economy.

Other Commerce R&D Activities.—Funding for smaller R&D programs in the Department, which include those in General Administration, the Bureau of the Census, the Economic Development Administration, and the National Telecommunications and Information Administration, are proposed at \$13 million in 1989, a decrease of \$4 million from the 1988 level.

DEPARTMENT OF THE INTERIOR

The R&D activities of the Department of the Interior principally derive from its broad-ranging responsibilities for management of the nation's natural resources, including developing energy and mineral resources, and restoring and preserving wildlife habitats. R&D programs also serve the needs of other Federal agencies and the private sector.

Obligations for the conduct of R&D for the Department of the Interior for 1989 are estimated at \$396 million. This represents a decrease of \$23 million from the 1988 level.

About 92 percent of the Department's 1989 funds for the conduct of R&D will be obligated by the Geological Survey (\$224 million), Fish and Wildlife Service (\$54 million), and the Bureau of Mines (\$86 million). Highlights of the 1989 research objectives of these and other departmental programs are described below.

The *Geological Survey* undertakes research on the extent, distribution, and character of the nation's water and other natural resources and on the geologic processes, structures, and hazards that affect the development and use of the land and physical environment. For 1989, obligations will decrease by \$12 million, to a total of \$224 million.

Research in 1989 will be directed toward:

- accurate appraisals of mineral resources and new improved methods of mineral exploration;
- development of basic data on geologic principles and processes;
- improvement of the scientific basis for appraisal and evaluation of water resources; and
- development and application of new technologies, including remote sensing, to prepare cartographic information.

The *Fish and Wildlife Service* supports research in the Service's laboratories and field stations and cooperative efforts with state fish and game departments. It also provides Federal aid to states for research on restoration of fish and wildlife resources. This research provides basic biological information about species numbers, population dynamics, ecological relationships, and habitat requirements. Obligations will total \$54 million in 1989.

The Fish and Wildlife Service will support research activities concerned with:

- the habitats of waterfowl, migratory and non-migratory birds, and mammals;
- the status and distribution of endangered and threatened species;
- impact of broad-scale environmental changes on fish and wildlife populations and habitat; and
- diseases of freshwater and anadromous fish.

The *Bureau of Mines* conducts basic and applied research across the minerals cycle to improve understanding of the principles of mining and minerals processing and to reduce associated health hazards. Obligations for the conduct of R&D are expected to decrease by \$10 million to \$86 million in 1989. This decrease in obligations is the result of proposed reductions in applied research, particularly in projects which are more appropriate for support by non-Federal sources. The 1989 budget reflects continued emphasis on strategic and critical minerals R&D activities and stresses:

- long-range, high-risk research in extractive metallurgy technology;
- development of domestic source substitutes for imported strategic and critical minerals;
- health-related research on the proper quality and quantity of air flow in underground mines; and
- long-term, generic research on mine disaster prevention, ground control, industrial hazards, explosives, and systems engineering.

Other Departmental Programs expect to obligate about \$33 million in 1989, an increase of about \$3 million from 1988.

DEPARTMENT OF TRANSPORTATION

The R&D program of the Department of Transportation is oriented toward providing the information and new technology needed for its own operational (e.g., air traffic control) programs and for regulatory (e.g., automotive and aircraft safety standards) programs. Obligations for the conduct of research and development by the Department are estimated at \$317 million for 1989, a decrease of \$9 million from 1988.

The *Federal Aviation Administration (FAA)* is expected to obligate \$165 million in 1989. This funding level is consistent with the needs of the National Airspace System Plan. Major initiatives include enhancing the capability of a wide range of radar systems to meet new operational requirements; continuing the Traffic Alert and Collision Avoidance System (TCAS) Program; increasing systems and airports capacity; continuing developmental efforts for Advanced Traffic Management (ATF) and Automated Enroute Traffic Control (AERA); continuing development of radars for detection and tracking of severe weather; and continuing emphasis on initiatives in aviation security through expedited development of devices for detection of weapons, explosives and flammable liquids.

The *National Highway Traffic Safety Administration* will obligate \$30 million for motor vehicle, highway safety research, and demonstrations including: National Occupant Protection, alcohol, enforcement and emergency services and the National Driver Register. In 1989, increases are requested for crashworthiness and

crash avoidance research, highway safety research, the National Occupant Protection Program, enforcement and emergency services and the National Driver Register.

The *Urban Mass Transportation Administration (UMTA)* is expected to obligate \$2 million to conduct research, training, and human resources programs in all phases of urban mass transportation services or contribute toward meeting total urban transportation needs at minimum costs. In addition, UMTA supports interdisciplinary research at colleges and universities including training of personnel to conduct further research or to obtain employment in urban mass transportation planning, construction, operation or management.

The *Federal Highway Administration* will obligate \$82 million to continue research programs in highway planning, design, construction, and maintenance to ensure an effective and efficient highway system. Research will also be conducted in identifying and correcting impediments to highway safety and improving common carrier safety.

The *Federal Railroad Administration* will obligate \$9 million in research and development efforts in support of safety regulation responsibilities.

The *U.S. Coast Guard* will obligate \$19 million to support research to maintain and improve search and rescue systems, environmental protection, marine safety, aids to navigation, the enforcement of laws and treaties, and activities which benefit all Coast Guard programs. The proposed FY 1989 figure represents no change over the FY 1988 level.

The *Research and Special Programs Administration* will obligate \$3 million for R&D in hazardous materials, pipeline safety, radio-navigation, transportation statistics, and emergency transportation.

The *Office of the Secretary* will obligate \$7 million for broad-based policy research on domestic and international transportation issues of importance to the nation, and research in support of licensing of expendable launch vehicles.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency's (EPA) Research and Development Program supports EPA's statutory and regulatory responsibilities to protect human health and the environment. Since 1984, four of EPA's eight major environmental laws have been substantially amended. The 1989 budget proposes \$374 million in total obligations, representing an increase of 7 percent above 1988, to meet environmental statutory mandates and to understand emerging environmental concerns. The 1989 budget emphasizes: (1) expanded efforts to understand the phenomena related to stratospheric ozone; (2) techniques for mitigating human exposure to

radon; (3) continued development of scientific information about acid deposition; (4) support of the 1987 Clean Water Act Amendments; and (5) reducing uncertainties in risk assessments.

The *air research* program will expand to further characterize the effects of stratospheric ozone depletion. Research on other emerging environmental concerns such as global climate change and indoor air pollution will continue. Research on ambient air quality standards and toxic hazardous air pollutants will also continue.

The *radon research* program will continue to demonstrate techniques of reducing exposure to indoor radon gas in a variety of housing structures. The number of mitigation demonstrations initiated in homes will be increased.

The *acid disposition* program will continue to support the objective of the National Acid Precipitation Assessment Program (NAPAP) Interagency Task Force which is to understand and predict the phenomenon of acid disposition. Such research will ultimately provide information and predictive tools for the 1990 Assessment Report to Congress on acid deposition.

The *water quality* research program will continue to support the mandates of the 1987 Clean Water Act Amendments. Research will emphasize risk assessments, monitoring methods, pretreatment, sludge, biological monitoring, complex effluent toxicity, and water assessments to control toxic pollutants. Research on wetlands will attempt to determine attainable standards and load limits of critical pollutants.

The *pesticides research* program will continue to develop methods to assess risks to human health and the environment from exposure to pesticide products. Research will be increased to support the evaluation of new technologies for destruction and disposal of pesticides cancelled or suspended under FIFRA. Research efforts on environmental effects from biotechnology products will continue.

The *toxic substances* research program will continue to support EPA's Office of Toxic Substances by performing research in the areas of test methods development and evaluation; structure activity relationships; environmental engineering and technology; and biotechnology. Technical support in the areas of exposure assessment/monitoring procedures and risk assessment methodologies will also continue.

The *hazardous waste* research program will develop scientific and technical information to support regulatory development and implementation. Alternatives to conventional means of disposing of and destroying wastes will continue to be evaluated as will controls for emissions from municipal waste combustors.

The *interdisciplinary* research program will expand to support a new program to reduce uncertainties in risk assessments. This research is designed to improve EPA's assessments of environmen-

tal and health risks in order to reduce uncertainties in risk management decisions.

The *Superfund* research program will continue to support EPA, States, and industry in resolving technical problems which inhibit the effective implementation of removal and remedial actions. In addition, research and development will support the commercialization of alternative and innovative treatment techniques for use in response actions through the Superfund Innovative Technology Evaluation (SITE) program.

Finally, the *leaking underground storage tanks (LUST)* program will provide technical support to EPA's Office of Underground Storage Tanks, EPA regions, States, and local agencies responsible for the implementation of the LUST Trust Fund Program. Technical support will focus on providing scientific expertise on low cost approaches for assessing site contamination and evaluating remedial technologies.

VETERANS' ADMINISTRATION

The Veterans' Administration (VA) conducts and administers an intramural program of medical, rehabilitation and health services research designed to improve the quality and increase the effectiveness of health care for veterans. In 1989, the VA will obligate \$216 million for the conduct of R&D.

The VA's medical research program covers a wide range of medical problems, with special emphasis on the health problems of women veterans, the biological processes of aging, the health consequences of exposure to Agent Orange, the health problems of former prisoners of war, the treatment of alcoholism, Acquired Immune Deficiency Syndrome (AIDS), and post traumatic stress disorder.

Rehabilitation research is committed to meeting the health care needs of aging, disabled veterans with state-of-the-art devices that minimize their disability and improve the quality of their lives. Rehabilitation research is making use of such concepts as: voice controlled robotics for the totally paralyzed; computer controlled electrical stimulators to restore function to paralyzed limbs; new ultra light materials for artificial limbs; advanced mobility aids for the blind using cellular radio networks and computer assisted hearing aids.

Health services research is putting in place an information network designed to generate and disseminate to health care systems managers, providers and consumers the kind of information that will help make the most effective use of research findings directed at improving health care services for veteran patients. Emphasis will be placed on such areas as technology transfer, aging, preventive health and cost effectiveness.

AGENCY FOR INTERNATIONAL DEVELOPMENT

Research and development activities of the Agency for International Development (AID) consist mainly of applied research to solve specific problems associated with basic human needs and social and economic research aimed at improving U.S. and host-country understanding of the barriers to development. Programs under AID reflect the administration's recognition of the importance of R&D in addressing the problems faced by the Third World. Over the years, AID has provided substantial support to research efforts undertaken by U.S. universities and international research centers such as the International Rice Research Institute in the Philippines.

Obligations by AID for the conduct of R&D are estimated at \$199 million for 1989, a decrease of \$9 million from 1988.

AID will continue to support research aimed at improving agricultural production capability, with an emphasis on efforts to overcome the mounting food crisis in Third World nations. R&D funds will also be devoted to two other critical problems: population growth, emphasizing methods of controlling increasing population growth rates in the developing countries, and energy supply, emphasizing renewable and nonconventional energy sources critical for development to proceed.

Significant research efforts are also being pursued in two other promising areas: oral rehydration therapy and a malaria vaccine. The former holds the promise of significantly reducing the incidence of child mortality associated with diarrheal diseases, currently estimated to claim the lives of over 1 million children annually. Similarly, AID-supported research on a malaria vaccine may lead to a breakthrough in controlling a disease which currently infects some 200 million people worldwide and is the leading cause of death in Third World nations.

OTHER AGENCY PROGRAMS

An additional 9 departments and agencies (listed in table J-2, footnote 1) will obligate an estimated \$585 million in 1989, for the conduct of R&D, an increase of about 5 percent from the 1988 level. Obligations by these agencies amount to less than 1 percent of all federally-funded programs in R&D. The programs of these agencies, like those of other agencies discussed above, are closely related to serving the agencies' missions.

Among the agencies in this category that expect to increase their obligations for R&D in 1989 are the U.S. Army Corps of Engineers, and the Departments of Housing and Urban Development and Treasury.

Table J-10 provides information on the long-term trends in Federal funding for the conduct of R&D.

Table J-10. TRENDS IN CONDUCT OF R&D

(Obligations in billions of dollars)

Year	Defense ¹	All other	Total	Basic research ²
1960.....	6.1	1.5	7.6	0.6
1961.....	7.0	2.1	9.1	0.8
1962.....	7.2	3.1	10.3	1.0
1963.....	7.8	4.7	12.5	1.2
1964.....	7.8	6.4	14.2	1.3
1965.....	7.3	7.3	14.6	1.4
1966.....	7.5	7.8	15.3	1.6
1967.....	8.6	7.9	16.5	1.8
1968.....	8.3	7.6	15.9	1.8
1969.....	8.4	7.2	15.6	1.9
1970.....	8.0	7.3	15.3	1.9
1971.....	8.1	7.4	15.5	2.0
1972.....	8.9	7.6	16.5	2.2
1973.....	9.0	7.8	16.8	2.2
1974.....	9.0	8.4	17.4	2.4
1975.....	9.7	9.3	19.0	2.6
1976.....	10.4	10.4	20.8	2.8
1977.....	11.9	11.6	23.5	3.3
1978.....	12.6	13.2	25.8	3.7
1979.....	13.6	14.5	28.1	4.2
1980.....	15.1	14.7	29.8	4.7
1981.....	17.8	15.3	33.1	5.0
1982.....	22.1	14.3	36.4	5.5
1983.....	24.5	13.9	38.4	6.4
1984.....	28.3	14.9	43.2	7.0
1985.....	33.4	16.1	49.5	7.8
1986.....	36.5	16.2	52.6	8.1
1987.....	38.4	17.6	56.1	9.0
1988 (estimate).....	40.3	19.7	60.0	9.7
1989 (estimate).....	41.2	21.3	62.5	10.3

¹ Includes military-related programs of the Departments of Defense and Energy.² Included in totals for conduct of R&D.