NASA Performance Plan

Fiscal Year 1999

February 1999

Table of Contents

Introduction

The Government Performance and Results Act (GPRA) passed by Congress and signed by the President in 1993 provides a new tool to improve the efficiency of all Federal agencies. The goals of GPRA are to:

- Improve Federal program management, effectiveness, and public accountability
- Improve congressional decisionmaking on where to commit the Nation's financial and human resources
- Improve citizen confidence in Government performance

The Act directs Executive Branch agencies to develop a customer-focused strategic plan that aligns activities with concrete missions and goals. The first plans were submitted in September 1998 as part of the Fiscal Year 1999 (FY99) budget process. These budget submissions were expected to support the goals expressed in the agency strategic plans. The Act also directs agencies to manage and measure results to justify congressional appropriations and authorizations. Six months after the completion of the fiscal year, agencies will report on the degree of success in achieving the goals and evaluation measures defined in the strategic and performance plans.

Processes within NASA's Strategic Management System provide the information and results for GPRA's planning and reporting requirements. The System is defined in the NASA Strategic Management Handbook (NASA Procedures and Guidelines 1000.2). Figure 1 illustrates the hierarchy of documentation for the Strategic Management System.

The NASA Strategic Plan (NASA Policy Directive 1000.1) defines the vision, mission, and fundamental questions of science and research that provide the foundation of the Agency's goals. The Plan describes four Strategic Enterprises that manage the programs and activities to implement our mission, answer the fundamental questions, and provide service to identified customers. The support systems for the Strategic Enterprises, defined as Crosscutting Processes, are also defined in the Strategic Plan.

The NASA FY1999 Final Performance Plan outlines selected measurements to evaluate progress the Agency intends to make in FY99 toward the achievement of its goals. The revisions in the FY1999 Final Performance Plan address inputs from our customers requesting that we: (1) provide better linkage to our budget, (2) incorporate additional information establishing the reasonableness of our performance targets, and (3) better identify the means we will use to verify our performance. This final version contains modifications to selected measures that appear in the initial FY 1999 Government Plan. These modifications reflect changes that have taken place since the performance measurements were submitted in the fall of 1997.

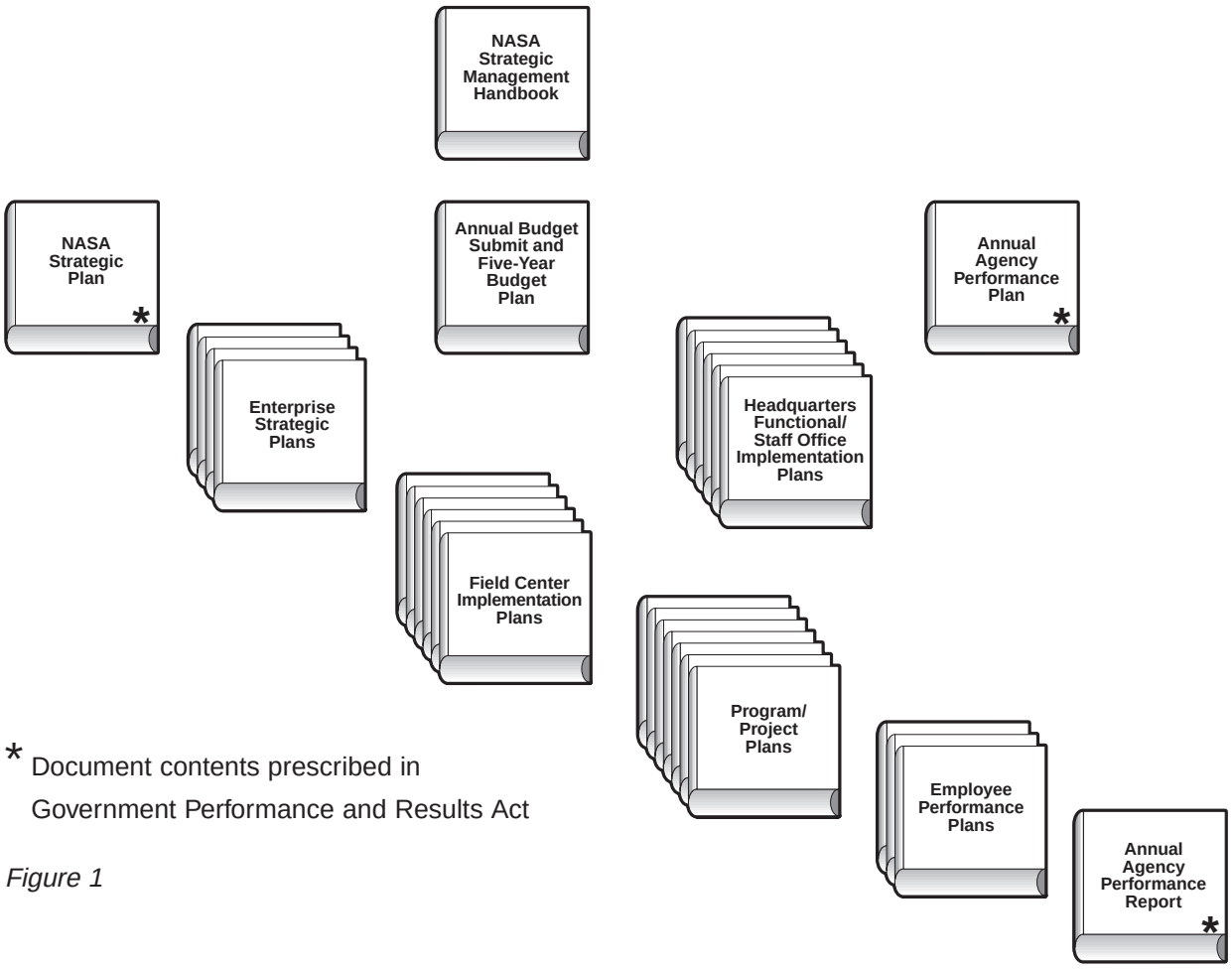
Many of NASA's goals and objectives span multiple years, as do the activities required to achieve them. The pursuit of expanding knowledge is challenging, and final results are often unpredictable. In research and development, expenditures made in one year may not pay dividends for a number of years, making it difficult to use annual measures of performance to demonstrate the relationship between resources provided in any given year and a potential outcome that occurs much later. Of necessity, we must include a relatively high percentage of measures of output to address the benefits to be realized as a result of the annual expenditures anticipated for the fiscal year. Furthermore, we often find that stakeholders outside the Agency determine the ultimate use of that knowledge; thus the ultimate outcome is frequently not within our control. For example, we do not control

when or whether the aeronautics community will incorporate a state-of-the-art advancement into its commercial aircraft production lines, nor can we guarantee that a developer of launch systems will take sufficient risk to fund the development the next generation of launchers based on technologies developed at our Centers.

The challenges of relating annual performance to a multiyear undertaking are inherent to all research and development efforts, and we will continue to continue to work toward the goal of making more effective linkages among the expenditure of resources, annual performance, and the realization of the desired long-range goals. Having noted the challenges of connecting annual expenditures with long-range goals, it is worth reiterating the importance of keeping the funding pipeline filled to ensure the downstream realization of our primary mission. It is anticipated that future versions of NASA's performance plans will incorporate the full investments that have been made prior to the year of record.

As with the Strategic Plan, NASA intends to revise and improve the content of future editions of this document. Agency managers will validate the performance measures in consultation with customers, employees, and stakeholders in the Administration, Congress, and other agencies. Similar consultations will be conducted with internal and external advisory committees.

NASA's Strategic Management System Documents



* Document contents prescribed in Government Performance and Results Act

Figure 1

NASA Vision Statement

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

NASA Mission Statement

To advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe and use the environment of space for research;

To explore, use, and enable the development of space for human and robotic endeavors in science and commerce;

To research, develop, verify, and transfer advanced aeronautics, space, and related technologies.

NASA Performance Plan

This document, as required by GPRA, describes performance measures and service levels for program activities requested in the FY99 budget. Performance goals are defined for NASA's Strategic Enterprises and Crosscutting Processes. The FY1999 NASA Performance Plan should be used in conjunction with the NASA Strategic Plan (NPD 1000.1) and the NASA Budget Estimates, Fiscal Year 1999 to obtain a complete understanding of the entire body of work being undertaken by the Agency in Fiscal Year 1999. The NASA Budget Estimates, Fiscal Year 1999 document provides the complete description of program activities, budget requirements, and performance measures. The NASA Performance Plan provides detail for only a subset of the information provided in the Budget Estimates publication.

NASA implements and executes its space and aeronautics programs and activities through four Strategic Enterprises. Each Enterprise has identified a unique set of goals, objectives, and strategies to meet the requirements of their primary customers. The four Enterprises are:

- Space Science
- Earth Science
- Human Exploration and Development of Space
- Aero-Space Technology

The Crosscutting Processes support the goals of the Agency and all four Enterprises. The Crosscutting Processes transform inputs, such as policies and resources, into outcomes, such as knowledge. The Processes are:

- Manage Strategically
- Provide Aerospace Products and Capabilities
- Generate Knowledge
- Communicate Knowledge

Each section of the Performance Plan includes the following:

- A description of the mission of the Enterprise or Crosscutting Process.
- The budget and Civil Service personnel required to support the Enterprise for FY 99–03.
- A description of the measurement and the performance target for FY99 (Where applicable, comparison data to previous years will be provided).
- A crosswalk relating the performance targets to the NASA budget structure.

NASA's Strategic Management System Roadmap

Vision, Mission, Questions, Roadmap and Goals, and Contributions to National Priorities

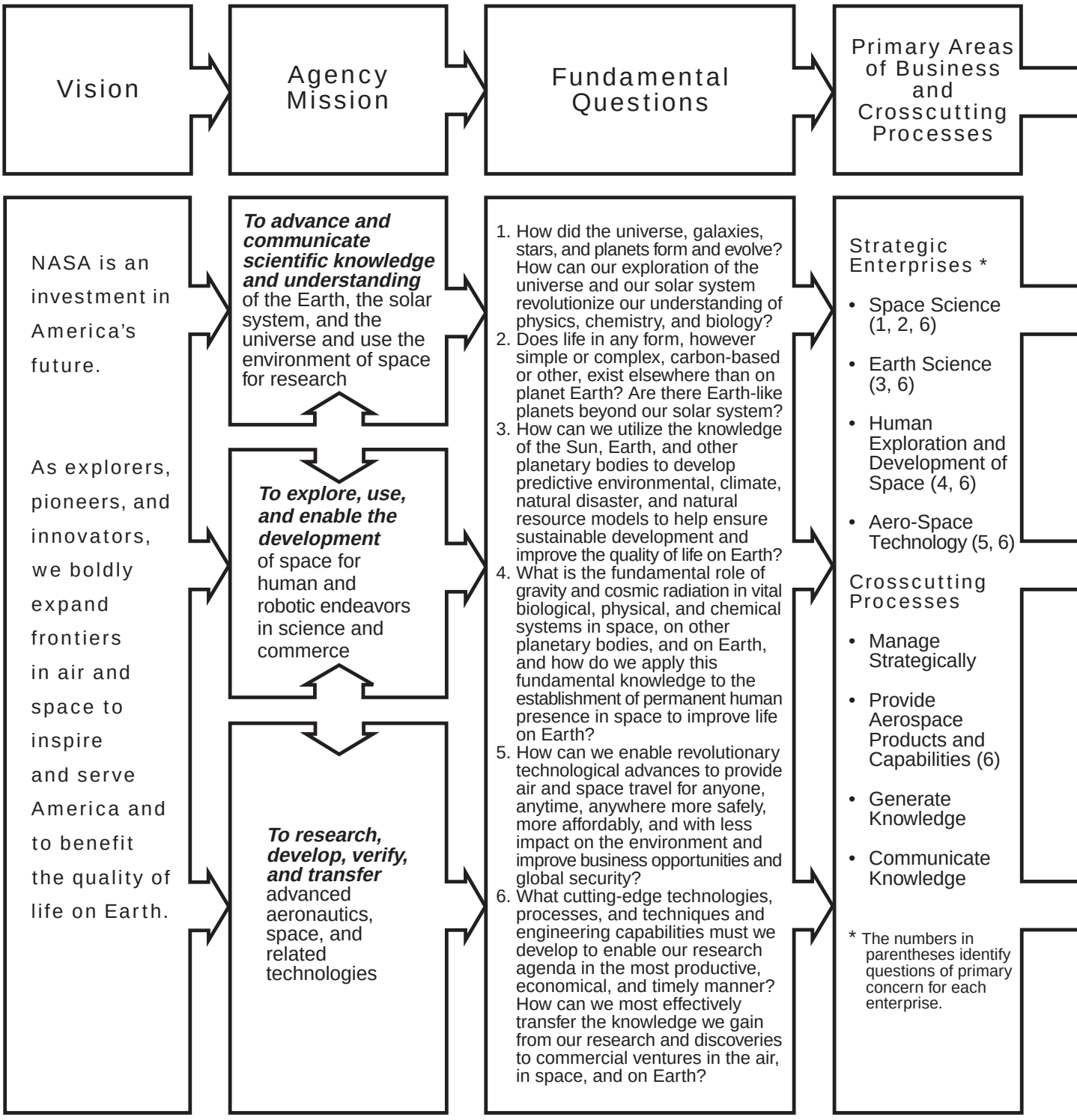
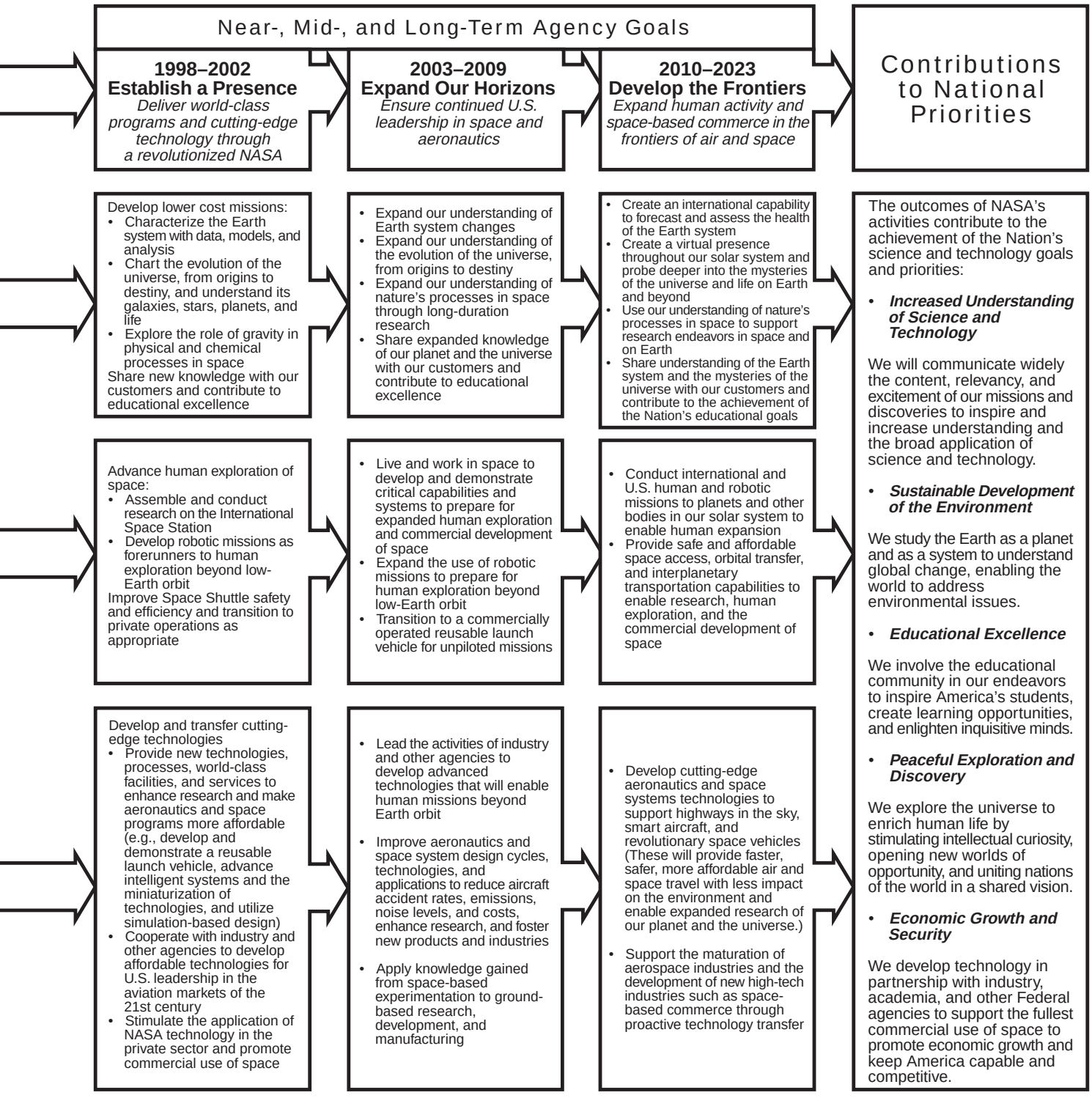


Figure 2


Near-, Mid-, and Long-Term Agency Goals
1998–2002
Establish a Presence
Deliver world-class programs and cutting-edge technology through a revolutionized NASA
2003–2009
Expand Our Horizons
Ensure continued U.S. leadership in space and aeronautics
2010–2023
Develop the Frontiers
Expand human activity and space-based commerce in the frontiers of air and space
Contributions to National Priorities
Develop lower cost missions:
• Characterize the Earth system with data, models, and analysis
• Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life
• Explore the role of gravity in physical and chemical processes in space
Share new knowledge with our customers and contribute to educational excellence
• Expand our understanding of Earth system changes
• Expand our understanding of the evolution of the universe, from origins to destiny
• Expand our understanding of nature's processes in space through long-duration research
• Share expanded knowledge of our planet and the universe with our customers and contribute to educational excellence
• Create an international capability to forecast and assess the health of the Earth system
• Create a virtual presence throughout our solar system and probe deeper into the mysteries of the universe and life on Earth and beyond
• Use our understanding of nature's processes in space to support research endeavors in space and on Earth
• Share understanding of the Earth system and the mysteries of the universe with our customers and contribute to the achievement of the Nation's educational goals
Advance human exploration of space:
• Assemble and conduct research on the International Space Station
• Develop robotic missions as forerunners to human exploration beyond low-Earth orbit
Improve Space Shuttle safety and efficiency and transition to private operations as appropriate
• Live and work in space to develop and demonstrate critical capabilities and systems to prepare for expanded human exploration and commercial development of space
• Expand the use of robotic missions to prepare for human exploration beyond low-Earth orbit
• Transition to a commercially operated reusable launch vehicle for unpiloted missions
• Conduct international and U.S. human and robotic missions to planets and other bodies in our solar system to enable human expansion
• Provide safe and affordable space access, orbital transfer, and interplanetary transportation capabilities to enable research, human exploration, and the commercial development of space
Develop and transfer cutting-edge technologies
• Provide new technologies, processes, world-class facilities, and services to enhance research and make aeronautics and space programs more affordable (e.g., develop and demonstrate a reusable launch vehicle, advance intelligent systems and the miniaturization of technologies, and utilize simulation-based design)
• Cooperate with industry and other agencies to develop affordable technologies for U.S. leadership in the aviation markets of the 21st century
• Stimulate the application of NASA technology in the private sector and promote commercial use of space
• Lead the activities of industry and other agencies to develop advanced technologies that will enable human missions beyond Earth orbit
• Improve aeronautics and space system design cycles, technologies, and applications to reduce aircraft accident rates, emissions, noise levels, and costs, enhance research, and foster new products and industries
• Apply knowledge gained from space-based experimentation to ground-based research, development, and manufacturing
• Develop cutting-edge aeronautics and space systems technologies to support highways in the sky, smart aircraft, and revolutionary space vehicles (These will provide faster, safer, more affordable air and space travel with less impact on the environment and enable expanded research of our planet and the universe.)
• Support the maturation of aerospace industries and the development of new high-tech industries such as space-based commerce through proactive technology transfer
The outcomes of NASA's activities contribute to the achievement of the Nation's science and technology goals and priorities:
• Increased Understanding of Science and Technology
We will communicate widely the content, relevancy, and excitement of our missions and discoveries to inspire and increase understanding and the broad application of science and technology.
• Sustainable Development of the Environment
We study the Earth as a planet and as a system to understand global change, enabling the world to address environmental issues.
• Educational Excellence
We involve the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds.
• Peaceful Exploration and Discovery
We explore the universe to enrich human life by stimulating intellectual curiosity, opening new worlds of opportunity, and uniting nations of the world in a shared vision.
• Economic Growth and Security
We develop technology in partnership with industry, academia, and other Federal agencies to support the fullest commercial use of space to promote economic growth and keep America capable and competitive.

NASA Fiscal Year 1999 Budget Request

The NASA FY99 budget request, as amended by the FY99 Appropriation and Initial FY99 Operating Plan (Figure 3), reaffirms the President's commitment to a balanced aeronautics and space program. This budget will support the Agency's priorities as directed by the National Space Policy and the President's Goals for a National Partnership in Aeronautics Research and Technology. NASA's priorities include a commitment to safety for human aeronautics and space flight, the assembly of the International Space Station, and the development of the Next Generation Launch Vehicle. The budget also provides support for an aggressive space science program, a program of long-term observation, research, and analysis of Earth from space, and revolutionary advancements that will sustain global U.S. leadership in civil aeronautics and space.

Under the FY1999 appropriations structure, the Mission Support appropriation carries a portion of the direct support required to execute the Enterprise goals and objectives, notably Research and Operations Support and Civil Service salaries and travel. As NASA moves into the era of full cost management, the budget for these supporting elements will be directly allocated to the programs and projects. The remaining direct costs, such as for mission-unique information technology support, are already incorporated into the program and project budgets; thus they are not identified as separate contributions. For informational purposes, the Enterprise sections of this plan will display the Civil Service staffing levels assigned to the Enterprise.

Fiscal Year 1999 Estimates
(In millions of Real Year Dollars)

	FY 99	FY 00	FY 01	FY 02	FY 03
NASA Total Budget	13,665	13,278	13,315	13,394	13,435
Space Science	2,119	2,207	2,308	2,387	2,568
Earth Science	1,414	1,492	1,494	1,449	1,407
Human Exploration and Development of Space	6,309	6,087	5,929	5,725	5,480
Aero-Space Technology	1,339	1,092	1,026	1,057	1,071
Mission Support, Academic Programs, Inspector General, and others	2,475	2,400	2,558	2,776	2,909
Civil Servant Full-Time Equivalents	18,519	17,818	17,628	17,580	17,517

Figure 3

Space Science Enterprise

Mission

The Space Science Enterprise mission is to solve mysteries of the universe, explore the solar system, discover planets around other stars, and search for life beyond Earth. Programs of the Enterprise chart the evolution of the universe from origins to destiny, as well as improve understanding of galaxies, stars, planets, and life. The Enterprise mission includes developing innovative technologies to support Space Science programs and making them available for other applications that provide benefits to the Nation. Knowledge and discoveries will be shared with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans.

Implementation Strategy

The Space Science Enterprise is developing new programs through the "faster, better, cheaper" approach. Program managers are encouraged to accept prudent risk, shorten development time of technologies and missions, explore new conceptual approaches, streamline management, and incorporate innovative methods and technologies to enhance efficiency and effectiveness. Collaborative efforts with other Federal agencies, such as the National Science Foundation, Department of Defense, and Department of Energy, as well as with international partners, continue to play a key role in the implementation strategy of the Enterprise.

The same spirit of innovation that embodies the Space Science flight programs applies to technology development. Long-term, high-risk, high-payoff technologies are key to implementing the Space Science mission. Technologies for advanced miniaturization, intelligent systems, autonomous operations, and simulation-based design will receive special attention in FY99.

Enterprise Resource Requirements

The President has requested the following budget for FY99 to FY03 to support the accomplishment of Space Science goals:

$M	FY 99	FY 00	FY 01	FY 02	FY 03
New Obligations Authority	2119	2207	2308	2387	2568
Civil Servants	1832	1781	1767	1776	1778

Performance Measures

To meet the near-term goals displayed in Figure 2 (page 7), the following objectives will be measured:

Objective—Solve mysteries of the universe

Space Science spacecraft will chart the evolution of the universe and enhance our understanding of galaxies, stars, and planets. The performance target will be to:

- Successfully launch seven spacecraft, within 10 percent of budget on average.

The Hubble Space Telescope will continue its observations of the universe. Hubble will complete a 3-year research project to determine the expansion rate of the universe (the Hubble constant), which determines its age. The performance target will be to:

- Measure the Hubble constant within an accuracy of about 10 percent, as compared to previous measurements that differ among themselves by a factor of two.

The Chandra X-ray Observatory (formerly the Advanced X-ray Astrophysics Facility) will record images and spectra of the Milky Way and other galaxies. The performance targets will be to:

- Record 25 images and spectra at a resolution of better than an arcsecond, five to ten times sharp-

er than images gathered earlier by the Einstein Observatory.
- Record data on approximately 12 compact stellar objects with a sensitivity 50 times greater than the Einstein Observatory.

The Rossi X-ray Timing Explorer (RXTE) was launched in December 1995. RXTE is measuring rapid fluctuations of x-rays from cosmic sources and will conduct experiments to test the General Relativity Theory. The performance target will be to:
- Observe physical phenomena 25,000 times closer to the event horizon of black holes than permitted with optical wavelength measurements.

Objective—Explore the solar system

The Near-Earth Asteroid Rendezvous (NEAR) will provide high-precision measurements of the shape and composition of the asteroid Eros, increasing our understanding of the early history of such bodies and the solar system. The performance targets will be to:
- Orbit Eros closer than 50 kilometers, 20 to 30 times closer than previous asteroid flybys.
- Measure the shape of Eros to an accuracy of 1 kilometer or better, about 10 times better than previous measurements, and measure the asteroid's mass to an accuracy of 20 percent.
- Complete the first direct compositional measurements of an asteroid.

The Lunar Prospector, launched in 1998, is designed to provide a complete geochemical map of the lunar surface. Research returns will also expand knowledge of the early history of the Moon. The performance targets will be to:
- Map the 75 to 80 percent of the Moon's surface not accessible during the Apollo missions conducted from 1969 to 1972.
- Provide definitive measurements of the weak lunar magnetic field.

The Transition Region and Coronal Explorer (TRACE) will observe energy propagation from solar disturbances beginning at the bottom of the visible solar atmosphere into the corona high above. The observations will be made at both high spatial resolution (a few arcseconds) and high time resolution (a few seconds). The analysis of these data will improve the understanding of solar activity and enhance the ability to predict its occurrence and effects in interplanetary space and on Earth. The performance target will be to:
- Provide these data with spatial resolution five times better than was collected from the Yohkoh Soft X-ray Telescope.

Objective—Discover planets around other stars

NASA will connect the twin 10-meter telescopes at the Keck Observatory in Hawaii into an 85-meter-baseline interferometer. This system will provide a capability to directly detect hot planets with Jupiter-size masses and characterize clouds of dust and gases permeating other planetary systems. The performance target will be to:
- Assemble and lab-test the interferometer beam combiner. This state-of-the-art system will approximately double observational efficiency by using a new approach to fringe detection.

Objective—Search for life beyond Earth

The Galileo spacecraft will continue to conduct investigations of Jupiter's moon, Europa, expanding the understanding of its history. Data collected will help determine the presence and state of water, a central consideration in understanding the possibility of life on the moon. The near-infrared imaging spectrometer on Galileo will provide data

on mineralogical characteristics of the observed portions of the surface, while gravitational and magnetometer measurements will yield insight about conditions below the surface. The performance targets will be to:

- Successfully complete and receive scientific data from at least 8 of 10 planned data-taking encounters with Europa.
- Bring the total mapping coverage to about 1 percent of the surface at about 30-meter resolution and multispectral coverage distributed over 50 percent of the surface at lower resolution.

NASA will establish a new Astrobiology Institute. The Institute will promote the publication of interdisciplinary research, demonstrate investigator interactions, and foster effective public education and outreach on research of life in the universe. To stimulate and facilitate multidisciplinary research, the Institute will feature an innovative virtual organizational structure. In FY98, NASA will select the participating organizations and the Institute Director. The performance target will be to:

- Initiate Institute operations by linking up to eight institutions and engaging approximately 50 investigators.

Objective—Investigate the composition, evolution, and resources on Mars, the Moon, and small bodies

Results from the Mars Global Surveyor will provide a greater understanding of geological processes of the planet. The Mars Global Surveyor will also provide data to determine whether or not water-related minerals are present on the surface. In addition to their immediate scientific interest, these data will provide information on potential landing sites for missions of human exploration at a later time. The performance targets will be to:

- Achieve the final science orbit.
- Measure the topography with 10-meter precision, about 100 times more accurate than previous measurements.
- Provide high-resolution 1.5-meter imaging data, 10 times more detailed than the best imaging from the 1976 Viking mission.
- Provide the first thermal infrared spectrometry of the planet.

Objective—Improve the reliability of space weather forecasting

During FY99, the Sun will approach the most active part of its 11-year cycle. Observations of solar activity will be conducted with a series of NASA spacecraft, including Polar, Wind, the Interplanetary Monitoring Platform-8 (IMP-8), and the Anomalous Composition Explorer (ACE). Data will also be collected from instruments on two Japanese spacecraft, Geotail and Yohkoh. Information from these combined missions will help characterize solar energetic particle emissions and will promote development of predictive tools to manage the effects of solar activity on terrestrial activity. Research on solar activity will contribute to designs for human interplanetary exploration. The performance target will be to:

- Achieve complete coverage (maximum and minimum) of the solar cycle, an increase from 35 percent.

Objective—Develop innovative technologies for Enterprise missions and for external customers

The New Millennium program will develop and validate innovative technologies and capabilities that will be required for Space Science missions planned for the next decade. The performance target will be to:

- Demonstrate an electric ion propulsion system with specific impulse 10 times greater than chemical propulsion systems.

The Micro-Arcsecond Metrology Testbed will demonstrate an improvement in positioning accuracy of optical surfaces. This accuracy is important for the development of high-performance interferometers. The performance target will be to:

- Demonstrate an improvement in measurement precision for optical pathlengths in laser light to the 100-picometer (million-millionths of a meter) range.

The Mars 98 Lander will demonstrate technologies to reduce mass and power consumption and increase instrument reach and dexterity. The performance target will be to:

- Demonstrate an advanced robotic manipulator with an order-of-magnitude performance improvement compared to the manipulator used on Viking in 1976.

Objective—Incorporate education and enhanced public understanding of science as integral components of Space Science missions and research

Space Science missions and research programs make a unique contribution to education and the public understanding of science. Providing a steady return of discoveries and new knowledge contributes to the accomplishment of this objective. The performance targets will be to:

- Account for 4 percent of the 150 "most important science stories" in the annual review by *Science News.*
- Account for no less than 25 percent of total contributions to the college textbook *Astronomy: From the Earth to the Universe.*
- Ensure that each new Space Science Enterprise mission initiated in FY99 will have a funded education and outreach program.
- Ensure that the Space Science Enterprise will complete an organized network of contacts by the end of FY99 to work with educators and space scientists to formulate and implement space science education and outreach programs. This network will be available to every State in the United States.

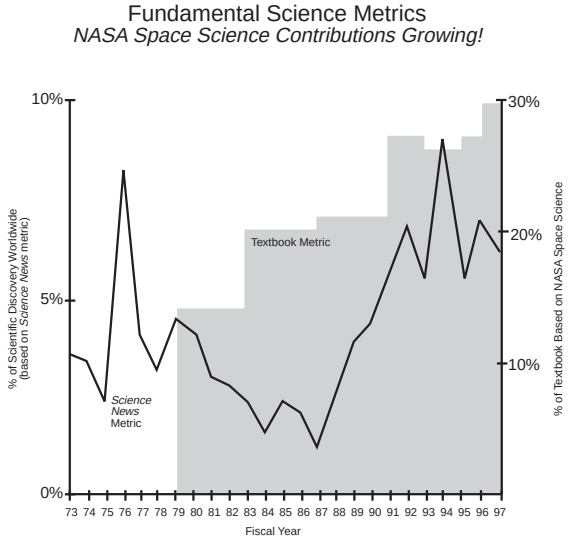


Figure 4

External Assessment

The Space Science Advisory Committee of the NASA Advisory Council will conduct an annual assessment of the Enterprise's near-term science objectives. The Committee will provide a qualitative progress measurement (Green, Yellow, or Red). "Green" will indicate that an objective was met; "Yellow" will indicate a concern that an objective was not fully accomplished; and "Red" will indicate that events occurred that prevented or severely impaired the accomplishment of the objective. The assessment will include commentary to clarify and supplement the qualitative measures.

Space Science—Chart 1

Space Science Enterprise Strategic Goals	Objectives	Final FY 1999 Performance Targets	99#
Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life	• Solve mysteries of the universe	• Successfully launch seven spacecraft, within 10 percent of budget on average.	S1
		• Complete 3-year Hubble Space Telescope research project to measure the Hubble constant within an accuracy of approximately 10 percent, as compared to previous measurements that differ among themselves by a factor of two.	S2
		• The Chandra X-ray Observatory will record 25 images and spectra of galaxies at a resolution of better than an arcsecond, five to ten times sharper than images gathered earlier by the Einstein Observatory.	S3
		• Chandra will record data on approximately 12 compact stellar objects with a sensitivity 50 times greater than the Einstein Observatory.	S4
		• The Rossi X-ray Timing Explorer (RXTE) will observe physical phenomena 25,000 times closer to the event horizon of black holes than permitted with optical wavelength measurements.	S5
	• Explore the solar system	• The Lunar Prospector will provide definitive measurements of the weak lunar magnetic field.	S10
		• The Transition Region and Coronal Explorer (TRACE) will provide data with a spatial resolution five times better than was collected from the Yohkoh Soft X-ray Telescope.	S11
		• The Near-Earth Asteroid Rendezvous (NEAR) will orbit EROS at a distance closer than 50 kilometers, 20–30 times closer than previous asteroid flybys.	S6
		• NEAR will measure the shape of EROS to an accuracy of 1 kilometer or better, about 10 times better than previous measurements, and measure its mass to an accuracy of 20 percent.	S7
		• NEAR will complete the first direct compositional measurements of an asteroid.	S8
		• The Lunar Prospector will geochemically map the 75–80 percent of the Moon's surface not accessible during the Apollo missions (1969–1972).	S9
	• Discover planets around other stars	• Assemble and lab-test the interferometer beam combiner (connecting the twin 10-meter telescopes at the Keck Observatory in Hawaii into an 85-meter-baseline interferometer), which will approximately double observational efficiency by using a new approach to fringe detection.	S12
	• Search for life beyond Earth	• Successfully complete and receive scientific data from at least 8 of 10 planned data-taking encounters with Europa.	S13
		• Bring the total mapping coverage to one percent of the surface at 30-meter resolution and multispectral coverage distributed over 50 percent of the surface at lower resolution.	S14
		• Initiate the Astrobiology Institute's operations by linking up to eight instititions and engaging approximately 50 investigators to promote publication of interdisciplinary research and foster effective public education and outreach on research on life in the universe.	S17
Use robotic missions as forerunners to human exploration beyond low-Earth orbit	• Investigate the composition, evolution, and resources of Mars, the Moon, and small bodies	• Achieve final science orbit of the Mars Global Surveyor	S15
		• The Mars Global Surveyor (MGS) will measure the topography with 10-meter precision, about 100 times more accurate than previous measurements.	S19
		• MGS will provide high-resolution 1.5-meter imaging data, 10 times more detailed than the best Viking data (1976).	S20
		• MGS will provide the first thermal infrared spectrometry of the planet.	S21
	• Improve the reliability of space weather forecasting	• Achieve complete coverage (maximum and minimum) of the solar cycle, an increase from 35 percent.	S22
Develop new critical technologies to enable innovative and less costly mission and research concepts	• Develop innovative technologies for Enterprise missions and for external customers	• The New Millennium program will demonstrate an electric ion propulsion system with specific impulse 10 times greater than chemical propulsion systems.	S23
		• Demonstrate an improvement in measurement precision for optical pathlengths in laser light to 100-picometer (million-millionths of a meter) range.	S24
		• The Mars 98 Lander will demonstrate an advanced robotic manipulator with improved performance of an order of magnitude compared to the manipulator used on Viking in 1976.	S25
Contribute measurably to achieving the science, math, and technology education goals of our Nation, and share widely the excitement and inspiration of our missions and discoveries	• Incorporate education and enhanced public understanding of science as integral components of Space Science missions and research	• Account for 4 percent of the 150 "most important science stories" in the annual review by *Science News.*	S26
		• Account for no less than 25 percent of total contributions to the college textbook *Astronomy: From the Earth to the Universe.*	S27
		• Each new Space Science Enterprise mission will have a funded education and outreach program.	S28
		• The Space Science Enterprise will complete an organized network of contacts by the end of FY99 to work with educators and space scientists to formulate and implement space science education and outreach programs.	S29

Space Science Budget Crosswalk—Chart 2

Strategic Objective / Budget Category	Chandra (formerly AXAF)	GPB	SOFIA	TIMED	SIRTF	Payloads	Explorers	Mars Surveyor	Discovery	Operating Missions	SR&T	R&PM	COF	Environmental	Education & Minority	SBIR	Performance Target Item # (Chart 1)	Other Objectives Addressed by Target (list)
Solve mysteries of the universe										X							S2	ESS, DPO
	X																S3, S4	
										X							S5	
Explore the solar system										X							S6, S7, S8	HDS
										X							S9, S10	HDS
										X							S11	HDS
Discover planets around other stars											X						S12	
Search for life beyond Earth										X							S13, S14	ESS
											X						S17	
Investigate the composition, evolution, and resources on Mars, the Moon, and small bodies										X							S15, S19, S20, S21	ESS
Improve the reliability of space weather forecasting										X							S22	ESS
Develop innovative technologies for Enterprise missions and for external customers											X						S23, S24, S25	ESS
Incorporate education and enhanced public understanding of science as integral components of Space Science missions and research															X		S26, S27, S28, S29	
																	S1	All

Note: X=Primary Contribution, Y=Secondary Contribution

Earth Science Enterprise

Mission

The Earth Science Enterprise mission is to understand the total Earth system and the effects of natural and human-induced changes on the global environment. Programs of the Enterprise advance the new discipline of Earth System Science, with a near-term emphasis on global climate change. Both space- and ground-based capabilities yield new scientific understanding of Earth and practical benefits to the Nation. Research results will contribute to the development of environmental policy and economic investment decisions. The Enterprise mission includes developing innovative technologies to support Earth Science programs and making them available for solving practical societal problems in agriculture and food production, water resources, and national resource management that provide benefits to the Nation. Knowledge and discoveries will be shared with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans.

Implementation Strategy

The Earth Science Enterprise conducts global and regional research requiring the vantage point of space. New programs will be developed and deployed through the "faster, better, cheaper" approach. Program managers are encouraged to accept prudent risk, shorten development time of technologies and missions, explore new conceptual approaches, streamline management, and incorporate innovative methods to enhance efficiency and effectiveness. Programs of the Enterprise contribute to the U.S. Global Change Research Program and are conducted in collaboration with ten other U.S. Federal agencies and 13 nations. Cooperative research programs with national and international partners will continue to play a key role in the implementation strategy of the Enterprise.

The same spirit of innovation that embodies the Earth Science flight programs applies to technology development. Long-term, high-risk, high-payoff technologies are key to implementing the Earth Science mission. The Enterprise priorities feature near-term product milestones on a path of long-term inquiry. Obtaining data from the private sector is an emerging feature of the Enterprise strategy. This will reduce Agency costs and encourage the growth of the commercial remote-sensing industry.

Enterprise Resource Requirements

The President has requested the following budget for FY99 to FY03 to support the accomplishment of Earth Science goals:

$M	FY 99	FY 00	FY 01	FY 02	FY 03
New Obligations Authority	1414	1492	1494	1449	1407
Civil Servants	1381	1412	1431	1428	1428

Performance Measures

To meet the near-term goals displayed in Figure 2 (page 7), the following objectives will be measured:

Objective—Understand the causes and consequences of land-cover/land-use change

The carbon cycle is one of the major Earth system processes influencing global climate. Key elements of NASA contributions are monitoring land-cover changes and measuring both terrestrial processes and ocean biological processes to estimate carbon uptake. An important unknown in the carbon cycle are seasonal rates of carbon storage in the ocean, which are caused by the activity of phytoplankton, which can be monitored from space. In addition to observations, NASA invests in research, data analysis, and modeling projects to understand the role of

marine and terrestrial ecosystems in the global carbon cycle. The performance targets will be to:

- Begin to refresh the global archive of 30-meter land imagery from Landsat 7, two to three times per year. A single global archive has not been constructed since the late 1970's. Landsat 7 also includes a 15-meter panchromatic band for the study of ecosystems disturbance.
- Begin to collect near-daily global measurements of the terrestrial biosphere (an index of terrestrial photosynthetic processes from which calculations of carbon uptake are made) from instruments on the EOS AM-1 spacecraft.
- Collect near-daily global measurements of ocean color (an index of ocean productivity from which calculations of ocean update of carbon are made).

Objective—Predict seasonal-to-interannual climate variations

In FY99, the Earth Science Enterprise will continue to invest in observations, research, data analysis, and modeling in this area. The Tropical Rainfall Measuring Mission (TRMM), launched in 1997, will gather information on rainfall in the tropics, where two-thirds of global precipitation falls. This is the key to understanding Earth's hydrological cycle, one of the three major processes driving climate change, and the global heat balance that drives seasonal change. The performance target will be to:

- Begin the second of a 3-year sequence of instantaneous measurements of rainfall rates and monthly accumulations in the global tropics. This will be the first-ever measurement of global tropical rainfall. Current uncertainty in global tropical rainfall estimates is 50 percent; TRMM data will reduce this uncertainty to 10 percent, an 80 percent improvement.

The QuikScat spacecraft, planned for launch in FY99, joins TRMM and the Ocean Topography Experiment/Poseidon (TOPEX/Poseidon) as a major El Niño/La Niña tracking asset. QuikScat will replace the NASA Scatterometer instrument that was lost in the failure of Japan's ADEOS spacecraft launched in 1997. The performance target will be to:

- Begin measurement of sea-surface wind speed and direction at a spatial resolution of 25-kilometer resolution over at least 90 percent of the ice-free global oceans every 2 days. This represents a resolution increase of a factor of two, as well as a 15-percent increase in coverage over previous measurements. Data from this mission will be used to improve the short-term weather forecasts.

Objective—Identify natural hazards, processes, and mitigation strategies for floods, droughts, and volcanoes

This is a new area of focus for NASA. The Earth Science Enterprise will use a combination of space-based and airborne assets to monitor and assess impacts of natural hazards, such as volcanoes, earthquakes, forest fires, hurricanes, floods, and droughts. The short-term objective is to assess impacts of these events on national and international agriculture, food production, water resources, commerce, and so forth. The long-term objective is to apply the scientific understanding toward developing a predictive capability.

In FY99, the Earth Science Enterprise will provide the technology and instruments to allow for the collection of interferometric Synthetic Aperture Radar (SAR) data. This will enable the first consistent global topography data record collected from space and will have a variety of applications, including assessing flood hazards, laying out new roadways and pipelines, and providing airline operators with detailed elevation data for remote areas. The performance target will be to:

- Provide instruments sufficient to create the first digital topographic map of 80 percent of Earth's land surface between 60°N and 56°S. The Shuttle Radar Topography Mission (SRTM) will be ready for launch by the end of FY99.

Additional performance targets for this objective will be to:

- Use the Global Positioning System (GPS) array in southern California to monitor crustal deformation on a daily basis with centimeter precision, and initiate the installation of the next 100 stations. The data will be archived at the Jet Propulsion Laboratory (JPL) and run in models, with the results given to the California Seismic Safety Commission and the Federal Emergency Management Agency to be used for earthquake warning.
- Ensure that data received from GPS receivers in low-Earth orbit will also be used to test improved algorithms for measuring atmosphere temperature. The data will serve as the future prototype for improving short-term weather forecasts globally. The data will be archived at JPL, and the results will be published in science literature.

Objective—Detect long-term climate change, causes, and impacts

In FY99, information on global and regional studies of temperature and precipitation drivers will be collected to measure the solar radiation reaching Earth. Clouds and aerosols (suspended particles in the atmosphere such as dust, sulfate, and smoke) determine the fate of this radiation in the atmosphere and impact Earth's energy balance. The Moderate Resolution Imaging Spectroradiometer (MODIS), the Multi-Angle Imaging Spectroradiometer (MISR), and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instruments will collect these measurements. These data, distributed through the Goddard Space Flight Center's Distributed Active Archive Center (DAAC) and combined with data from the Clouds and Earth's Radiant Energy System (CERES), will enable NASA to estimate Earth's solar and infrared radiative fluxes, which in turn will determine the heating and cooling of Earth and its atmosphere. The current uncertainty in Earth's radiation balance is about 15W/m^2 monthly mean over 100-kilometer by 100-kilometer areas. The performance targets for these instruments will be to:

- Begin to conduct daily observations of cloud properties, such as extent, height, optical thickness, and particle size.
- Map aerosol formation, distribution, and sinks over the land and oceans.
- Achieve significant reduction in the uncertainty in components of Earth's radiation balance (that is, improved angular models leading to an estimated error reduction in regional-scale monthly average net radiation of about 50 percent).

Objective—Understand the causes of variation in ozone concentrations and distribution in the upper and lower atmosphere

NASA's contribution in this area is to develop and operate space-based and airborne instruments that will map the fluctuations in ozone and related constituent gas in the atmosphere. In addition, NASA has a focused research and modeling effort in this area.

The Total Ozone Mapping Spectrometer (TOMS) will collect information of the ozone content of the total column of Earth's atmosphere. The performance target will be to:

- Use new retrieval methods to collect and analyze three new data products, including surface ultraviolet, tropospheric aerosols, and, in certain regions, tropospheric columns. Together with

SBUV/2 data, there will now be a continuous 20-year data set for total ozone that will measure the ultimate effectiveness of the Montreal Protocol on substances that deplete the ozone layer. These data are also useful in routing aircraft around areas of concentrated volcanic dust. These new and extended data products will be made available on the TOMS web site for dissemination and access to a broader community than just NASA-sponsored scientists.

The Stratospheric Aerosol and Gas Experiment III (SAGE III) will be launched to provide measurements of the distribution of trace constituents, temperature, aerosols, and cloud presence and their vertical distribution in the atmosphere. The performance target will be to:

- Improve the collection and analysis of measurements provided by SAGE II. These improvements include: lunar occultation capability allowing for new nitrogen trioxide (NO_3) and chlorine dioxide (OClO) measurements; additional wavelength sampling providing direct measurements and ability to retrieve aerosols throughout the troposphere; and appreciably higher spectral resolution allowing significantly improved distributions of water vapor and ozone in the upper troposphere and lower stratosphere. This represents approximately a two-thirds reduction in error in near-tropopause water vapor measurements, as well as extension of ozone measurements into midtroposphere with 10- to 15-percent errors. Such data were not available before.

Additional performance targets in this area will be to:

- Initiate the full Southern Hemisphere Additional Ozonesonde network to obtain the first-ever climatology of the upper tropospheric ozone in the tropics.
- Continue the detailed multi-aircraft study of troposphere chemistry over the tropical Pacific Ocean, especially the contribution of long-range transport of air from South America and Africa to otherwise unpolluted areas. Complete the field measurements phase of PEM-Tropics-B (rainy season) with an improved payload that has resulted from an initiative to develop a smaller, lighter payload with equal or better performance than PEM-Tropics-A (dry season). The results will be fully analyzed and published.
- Measure surface levels of chlorine- and bromine-containing chemical compounds addressed under the Montreal Protocol to document the decreasing concentrations of the regulated compounds and the rising concentrations of their replacements to quantify the decrease in total halogen abundance in the lower atmosphere. The data will be provided to researchers supporting the World Meteorological Organization (WMO) assessment process.

Objective—Improve dissemination of Earth Science research results

The dissemination of information resulting from Earth Science research is accomplished through the Earth Observing System Data and Information System (EOSDIS), and it will be a high priority in FY99. Distribution systems will be improved, and new methods will be developed to place data in the hands of Earth Science customers in a timely manner through open, distributed, and responsive data system architectures. EOSDIS performance targets will be to:

- Make Earth science data on land surface characteristics, ocean surface conditions, and climate available to users within 5 days.
- Increase the volume of data archived by 10 percent compared to FY97 (126 terabytes).

- Increase the number of distinct customers by 20 percent compared to FY97 (699,000 distinct customers).
- Increase products delivered from the DAAC's by 10 percent compared to FY97 (3,171,000 data products).

Objective—Increase the public's understanding of Earth System Science through education and outreach

Earth Science missions and research programs make a unique contribution to education and the public's understanding of Earth Science. Providing a steady return of discoveries and new knowledge contributes to the accomplishment of this objective. The Enterprise will continue to award fellowships through NASA's Graduate Student Fellowship and Training Programs. The performance targets will be to:

- Award 50 new graduate student/education research grants and 20 early career postdoctoral fellowships in Earth Science.
- Conduct at least 300 workshops to train teachers in the use of Earth Science Enterprise education products.
- Increase the number of schools participating in Global Learning and Observations to Benefit the Environment (GLOBE) from 5,900 in FY98 to 8,000 in FY99, a 35-percent increase. Increase the number of participating countries from 70 in FY98 to 72 in FY99.

Objective—Develop and transfer advanced remote-sensing technology

In collaboration with partners in industry and academia, the Enterprise will develop and demonstrate new technologies of value to remote-sensing research. The performance targets will be to:

- Demonstrate a new capability to double the calibration quality for moderate-resolution land imagery.
- Transfer at least one technology development to a commercial entity for operational use.
- Advance at least 25 percent of funded instrument technology developments one Technology Readiness Level (1 TRL) to enable future science missions and reduce their total cost.

Objective—Extend the use of Earth Science research for national, State, and local applications

The performance targets will be to:

- Establish at least five new Regional Earth Science Applications Centers.
- Establish at least eight new projects, with the U.S. Department of Agriculture, in the areas of vegetation mapping and monitoring, risk and damage assessment, and resource management and precision agriculture.
- Complete the solicitation for at least seven cooperative agreements with State and local governments in land-use planning, land capability analysis, critical areas management, and water resources management.

Objective—Support the development of a robust commercial remote-sensing industry

NASA is committed to providing technical assistance and advice to companies developing the commercial remote-sensing market opportunities. The performance target will be to:

- Establish at least 75 commercial partnerships in "value-added" remote-sensing product development, an increase of 100 percent from 37 in FY97.

Objective—Make major scientific contributions to national and international environmental assessments

Because of the nature of the discipline, it is vital that Earth Science research be conducted through cooperation and partnerships with other agencies

and with other countries. The Enterprise will continue to contribute scientific knowledge and observations and modeling results to national and international scientific environmental assessments. The performance targets will be to make significant contributions to two national and two international scientific assessments, including:

- Atmospheric Effects of Aviation, in collaboration with the Federal Aviation Administration. The contributed model results of the climate effects of measured aircraft emissions will be provided to the Intergovernmental Panel on Climate Change (IPCC).
- U.S. regional/national assessment(s) in partnership with U.S. Global Change Research Program agencies.
- Provide a lead chapter author as well as most of the global scale data to the WMO Ozone Assessment.
- Provide global-scale observations and analyses for the IPCC Assessment Report, sponsored by the United Nations Environment Programme and WMO.

General Earth Science performance measure—Successfully launch spacecraft

The Earth Science Enterprise will successfully launch three spacecraft, within 10 percent of budget on average.

External Assessment

The Earth Science Advisory Committee of the NASA Advisory Council will conduct an annual assessment of the Enterprise's near-term science objectives. The Committee will provide a qualitative progress measurement (Green, Yellow, or Red). "Green" will indicate that the objective was met; "Yellow" will indicate a concern that an objective was not fully accomplished; and "Red" will indicate that events occurred that prevented or severely impaired the accomplishment of the objective. The assessment will include commentary to clarify and supplement the qualitative measures.

Earth Science—Chart 3

Earth Science Enterprise Strategic Goals	Objectives	Final FY 1999 Performance Targets	99#
Expand scientific knowledge by characterizing the Earth system	• Understand the causes and consequences of land-cover/ land-use change	• Refresh the global archive of 30m land imagery from Landsat 7, two to three times per year. A single global archive has not been constructed since late 1970's. This will include a 15m panchromatic band.	Y1
		• Collect near-daily global measurements of the terrestrial biosphere (index of terrestrial photosynthetic processes from which calculations of carbon uptake are made) from instruments on EOS AM-1.	Y2
		• Collect near-daily measurements of ocean color (index of ocean productivity from which calculations of ocean update of carbon are made).	Y3
	• Predict seasonal-to-interannual climate variations	• TRMM will begin the second of a 3-year sequence of instantaneous measurements of rainfall rates and monthly accumulations in the global tropics. This will be the first measurement of global tropical rainfall. Current uncertainty is 50 percent. TRMM data will reduce uncertainty to 10 percent.	Y4
		• The QuikScat spacecraft will provide 25km resolution wind speed and direction measurements over at least 90 percent of the ice-free global oceans every 2 days. This represents a resolution increase of a factor of two and a 15-percent increase in coverage over previous measurements.	Y5
	• Identify natural hazards, processes, and mitigation strategies for floods, droughts, and volcanoes	• The Enterprise will provide the technology and instruments to create the first digital topographic map of 80 percent of Earth's land surface, everything between 60°N and 56°S. SRTM will be ready to launch in September 1999.	Y6
		• Use GPS array in southern California to monitor crustal deformation on a daily basis with centimeter precision; initiate installation of the next 100 stations. Data will be archived at JPL and run in models, with results given to the California Seismic Safety Commission and FEMA.	Y7
		• Use GPS data to test improved algorithms for sounding the atmosphere with the occulted GPS signal. Data will be archived at JPL and results published in science literature.	Y8
	• Detect long-term climate change, causes, and impacts	• MODIS, MISR, ASTER, and CERES (AM-1 instruments) will begin to conduct daily observations of cloud properties such as extent, height, and optical thickness, and particle size. Data will be distributed through the Goddard DAAC.	Y9
		• AM-1 will map aerosol formation, distribution, and sinks over the land and oceans.	Y10
		• The AM-1 instrument will achieve a 40-percent reduction in the uncertainty in Earth's radiation balance (that is, improved angular models leading to an estimated error reduction in regional-scale monthly average net radiation of about 50 percent).	Y11
	• Understand the causes of variation in ozone concentrations and distribution in the upper and lower atmosphere	• TOMS data will be used for new retrieval methods to collect and analyze three new data products, including surface ultraviolet, tropospheric aerosols, and tropospheric columns. With SBUV/2 data, TOMS will make a continuous 20-year data set for total ozone-measuring effectiveness of Montreal Protocol. New and extended data products will be made available on the TOMS web site.	Y12
		• SAGE III will improve the collection and analysis of measurements provided by SAGE II by adding these new features: new nitrogen trioxide and chlorine dioxide measurements, additional wavelength sampling to directly measure and retrieve aerosols throughout the troposphere, and higher spectral resolution.	Y13
		• Initiate the full Southern Hemisphere Additional Ozonesonde network to obtain the first-ever climatology of upper tropospheric ozone in the topics.	Y14
		• With data from other atmospheric ozone programs, continue the detailed multi-aircraft study of troposphere chemistry over the tropical Pacific Ocean, especially the contribution of long-range transport of air from South America and Africa to unpolluted areas. Complete the field measurements phase of PEM-Tropics-B (rainy season) with an improved payload that has resulted from an initiative to develop a smaller, lighter payload with equal or better performance than PEM-Tropics-A (dry season). Results will be fully analyzed and published.	Y15
		• With data from other atmospheric ozone programs, measure surface levels of chlorine- and bromine-containing chemical compounds addressed in the Montreal Protocol to document decreasing concentrations of regulated compounds and inceasing concentrations of replacement compounds. Analyses will be provided to researchers supporting the WMO assessment process.	Y16
• Disseminate information about the Earth System	• Improve dissemination of Earth Science research results	• EOSDIS will make available data on prediction, land surface, and climate to users within 5 days.	Y17
		• EOSDIS will increase the volume of data archived by 10 percent compared to FY97 (at 126 terabytes). Goddard has been collecting trend data since FY94.	Y18
		• EOSDIS will increase the number of distinct customers by 20 percent compared to FY97 (at 699,000 distinct customers). Goddard has been collecting trend data since FY94.	Y19
		• EOSDIS will increase products delivered from the DAAC's by 10 percent compared to FY97 (at 3,171,000 data products). Goddard has been tracking this information since FY94.	Y20

Earth Science—Chart 3 (continued)

Earth Science Enterprise Strategic Goals	Objectives	Final FY 1999 Performance Targets	99#
• Disseminate information about the Earth System	• Increase public understanding of Earth System Science through education and outreach	• Award 50 new graduate student research grants and 20 early career postdoctoral fellowships in Earth Science.	Y21
		• Conduct at least 300 workshops to train teachers in use of Earth Science Enterprise education products.	Y22
		• Increase number of schools participating in GLOBE to 8,000, from 5,900 in FY98, a 35-percent increase; increase participating countries from 70 in FY98 to 72.	Y23
• Enable the productive use of Earth Science and technology in the public and private sectors	• Develop and transfer advanced remote-sensing technologies	• Demonstrate a new capability to double the calibration quality for moderate-resolution land imagery.	Y28
		• Annually transfer at least one technology development to a commercial entity for operational use.	Y29
		• Annually advance at least 25 percent of funded instrument technology developments 1 TRL.	Y30
	• Extend the use of Earth Science research for national, State, and local applications	• Establish at least five new Regional Earth Science Applications Centers.	Y31
		• Establish at least eight new projects, with USDA, in the areas of vegetation mapping and monitoring, risk and damage assessment, and resource management and precision agriculture.	Y32
		• Complete solicitation for at least seven cooperative agreements with State and local governments in land-use planning, land capability analysis, critical areas management, and water resources management.	Y33
	• Support the development of a robust commercial remote-sensing industry	• Establish at least 75 commercial partnerships in “value-added” remote-sensing product development, an increase from 37 over FY97.	Y34
	• Make major scientific contributions to national and international environmental assessments	• Contribute model results of climate effects of measured aircraft emissions and provide to the IPCC Assessment Report.	Y24
		• Make significant contributions to U.S. regional/national assessments in partnership with U.S. Global Change Research Program agencies.	Y25
		• Make significant contributions to WMO Ozone Assessment by providing a lead chapter author as well as most of the global-scale data.	Y26
		• Provide lead chapter author and most of the global-scale data and contributing researchers to the IPCC Assessment Report, sponsored by United Nations Environment Programme and WMO.	Y27
• Expand scientific knowledge by characterizing the Earth System	• Successfully launch spacecraft	• The Enterprise will successfully launch three spacecraft, within 10 percent of budget on average.	Y35

Earth Science Budget Crosswalk—Chart 4

Strategic Objective	Budget Category	EOS	Earth Probes	Operating Missions	AR&DA	Globe	R&PM	COF	Environmental	Education & Minority	SBIR	Performance Target Item # (Chart 2)	Other Objectives Addressed by Target (list)
Understand the causes and consequences of land-cover/ land-use change		X										Y1, Y2	
		X		Y	Y							Y3	
Predict seasonal-to-interannual climate variations				X	Y							Y4	
		X			Y							Y5	
Identify natural hazards, processes, and mitigation strategies for floods, droughts, and volcanoes												Y6	
			Y		X							Y7, Y8	
Detect long-term climate change, causes, and impacts		X										Y9, Y10	
		X			X							Y11	
Understand the causes of variation in ozone concentrations and distribution in the upper and lower atmosphere				Y	X							Y12	
		X			Y							Y13	
					X							Y14, Y15, Y16	
Improve dissemination of Earth Science results		X										Y17, Y18, Y19, Y20	

Note: X=Primary Contribution, Y=Secondary Contribution

Earth Science Budget Crosswalk—Chart 4 (continued)

Strategic Objective / Budget Category	EOS	Earth Probes	Operating Missions	AR&DA	Globe	R&PM	COF	Environmental	Education & Minority	SBIR	Performance Target Item # (Chart 2)	Other Objectives Addressed by Target (list)
Increase public understanding of Earth System Science through education and outreach				X							Y21	
					X				Y		Y22	
					X						Y23	
Make major scientific contributions to national and international environmental assessments				X							Y24, Y25, Y26, Y27	
Develop innovative technologies for Enterprise missions and for transfer to external customers	X										Y28, Y29, Y30	
Extend the use of Earth Science research for national, State, and local applications				X							Y31, Y32, Y33	
Support the development of a robust commercial remote sensing industry				X							Y34	
Successfully launched spacecraft	X										Y35	
Note: X=Primary Contribution, Y=Secondary Contribution												

Human Exploration and Development of Space Enterprise

Mission

The Human Exploration and Development of Space (HEDS) Enterprise mission is to open the space frontier by exploring, using, and enabling the development of space to expand human experience into the far reaches of space. The Enterprise mission includes developing innovative technologies to support HEDS programs and making them available for other applications that provide benefits to the Nation. Knowledge and discoveries will be shared with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans.

Implementation Strategy

The HEDS Enterprise strategy is implemented by two program offices: the Office of Space Flight and the Office of Life and Microgravity Sciences and Applications (OLMSA).

The Office of Space Flight strategy to contribute to the HEDS mission consists of three major components: safety and performance upgrades; Space Shuttle operations; and the assembly of the International Space Station (ISS). Safety and performance upgrades provide for the modifications and improvements of ground facilities and Space Shuttle capabilities, the replacement of obsolete systems, and the expansion of safety and operating margins. Investments in Space Shuttle operations include hardware production, ground processing, launch and landing operations, flight crew operations, training, logistics, and sustaining engineering. The implementation strategy for ISS begins with Phase II of the program. This phase begins with the launch of the U.S.-owned/Russian-launched Functional Cargo Block (FGB) and concludes with the launch of the Airlock on Flight 7A.

The OLMSA strategy to contribute to the HEDS mission also consists of three components. OLMSA supports fundamental research driven by an emphasis on expanding scientific knowledge. Its focus on mission-driven research improves knowledge and technology for human space flight. The application-driven research of OLMSA seeks to transfer knowledge, expertise, and technology from HEDS missions to other uses that provide benefits to the Nation.

Enterprise Resource Requirements

The President has requested the following budget for FY99 to FY03 to support the accomplishment of HEDS goals:

$M	FY 99	FY 00	FY 01	FY 02	FY 03
New Obligations Authority	6309	6087	5929	5725	5480
Civil Servants	6220	5724	5593	5532	5428

Performance Measures

Note: The goals and objectives of the HEDS Enterprise are undergoing revision. The following objectives are consistent with previous versions of the FY99 Performance Plan but do not map to the currently published NASA Strategic Plan in a one-to-one fashion. The table at the end of this section provides a crosswalk from the older, published 1998 NASA Strategic Plan to the current performance targets. HEDS developed the performance targets within the framework of the goals and objectives provided in the text section.

Goal: Explore the role of gravity in physical, chemical, and biological processes

Objective—Enable the research community to use gravity as an experimental variable

The microgravity environment affords substantially reduced buoyancy forces, hydrostatic pressures, and sedimentation rates, allowing gravity-related phenomena and phenomena masked by gravity on Earth to be isolated and controlled. This environment allows measurements to be made with an accuracy that cannot be obtained on Earth. In partnership with the science community, HEDS identifies promising areas for space biological and physical science research. This partnership also supports technologies to improve U.S. competitiveness in these areas of research. Examples include glasses, ceramics, polymers, and biologically inspired "smart" materials. The performance targets will be to:

- Support an expanded research program of approximately 800 investigations, an increase of approximately 9 percent over FY98.
- Publish 90 percent of FY98 science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make it available on the Internet.

NASA will establish a new National Center for Evolutionary Biology. The Center will lead a national research effort on the evolution of mechanisms that sense gravity and developmental mechanisms by which multicellular organisms orient themselves with respect to gravity. The Center will also focus on the study of the interaction of gravity with the evolution of life. OLMSA's Life Sciences Division will lead this effort and will involve the Office of Space Science and the Office of Earth Science so that NASA will assume a national leadership role in evolutionary biology that is clearly integrated and coordinated among different program offices. The performance target will be to:

- Establish a National Center for Evolutionary Biology with participation of at least five research institutions and engaging at least 20 investigators.

NASA and the National Institutes of Health (NIH) selected a series of space flight experiments to use the microgravity environment to investigate fundamental aspects of the nervous system in a microgravity environment and to advance our understanding of changes in the nervous system function in space. Designated the Neurolab program, this work is part of the Federal Government's activities for the Decade of the Brain (1990–1999) and will lay the groundwork for NASA-NIH cooperative research on the ISS.

The Neurolab, launched on the Space Shuttle in 1998 on STS-90, performed international research in brain function and behavior. Experiments included studies on blood pressure control; sleep and wake cycles regulation; posture, balance, and coordination; and developmental neurobiology. New experimental technologies were introduced to support this research. The Neurolab program will contribute to improving the clinical diagnosis of balance disorders and sleep abnormalities in addition to providing new fundamental knowledge of how the nervous system develops, processes information, and changes in response to stimuli. The performance targets will be to:

- Publish a report of comparison of three different biological models to understand the influence of gravity on the nervous system.
- Publish a report defining the time course adaptations in the balance system to altered gravitational environments.

One of the goals of the Shuttle-*Mir* research program was to conduct peer-reviewed, precursor scientific research in preparation for the ISS. Research conducted on *Mir* missions increased the understanding necessary to develop effective countermeasures to be implemented on the ISS. *Mir* experience indicates that the current countermeasures were not effective in maintaining crew bone and muscle. The *Mir* radiation project indicated that the South Atlantic Anomaly (SAA) moved 250 miles north and west since the early 1970's. The research showed that flight crews received 90 percent of the radiation doses during the short time the spacecraft is in the SAA. *Mir* plant research demonstrated that some species of plants can successfully grow and develop in microgravity. In a *Mir* plant growth unit, a radish-type plant grew from a seed and produced new seeds, and new plants were grown from the space-produced seeds. The *Mir* missions have also provided insight into long-duration cell tissue culturing and have proven novel technologies to increase the number of protein crystal samples that can be accommodated in a standard growth chamber by up to a factor of 30. The performance targets will be to:

- Document *Mir* data lessons learned to facilitate ISS biomedical and countermeasure research.
- Document *Mir* data lessons learned to facilitate ISS research in fundamental biology and regenerative life support.
- Analyze *Mir* data to achieve a 3-year jump-start for cell culture and protein crystal growth research, and document analyses and lessons learned.
- Document *Mir* radiation research data to facilitate ISS extravehicular activity (EVA) planning.

The Microgravity Science Laboratory (MSL-1) and MSL-1 reflight carried major NASA-developed instruments for research in combustion science and fluid physics. It also used German-developed hardware to conduct research in materials science. An analysis of the mission has produced revolutionary data to improve our understanding of combustion and soot formation processes. This understanding is important because 85 percent of U.S. energy is produced through combustion processes. Combustion is also a major contributor to pollution, which affects health.

One major problem in foundry technology is controlling the microstructure of a casting by controlling the rate of new solid particle (nucleation rate) formation as the liquid metal cools and subsequently freezes. Experiments processed in MSL-1's unique, German-developed levitating furnace facility yielded the first measurements of specific heat and thermal expansion of glass-forming metallic alloys. These measurements—never taken on Earth before—are fundamental measurements necessary for modeling the industrial materials systems needed to manufacture new and better products. The Physics of Hard Sphere experiment, which examined changes that occur during the transition of a substance from liquid to solid and solid to liquid, offered insights into phenomena that could improve the design of metallic alloys and processing techniques. Questions addressed by the Physics of Hard Sphere experiment include:

- What is the volume fraction at which dispersions of hard spheres freeze, melt, and become glasses?
- What is the equilibrium structure associated with each phase?
- What are the dynamics of Brownian fluctuations within each phase?
- What are the kinetics of the nucleation and growth of the crystalline phase?

The performance targets will be to:

- Improve predictive capabilities of soot processes by at least 50 percent through the analysis of MSL-1 data, and publish the results in peer-reviewed open literature.
- Use MSL-1 results to eliminate one of the three primary fluid flow regimes from consideration by casting engineers, and publish this result in peer-reviewed literature. Casting engineers may use this information to improve metal casting processes in industry.
- Use data obtained from fluid physics experiments on suspensions of colloidal particles on MSL-1 to answer fundamental questions in condensed matter physics regarding the transition between liquid and solid phases, and publish data on the transition from liquids to solids and the results in peer-reviewed open literature.

Goal: Continue to open and develop the space frontier; develop and assemble the ISS and utilize it to advance scientific, exploration, engineering, and commercial activities; and provide safe and affordable human access to space

Objective—Improve Space Shuttle program operations by safely flying the manifest and aggressively pursuing a systems upgrade program

The Space Shuttle program will continue the Safety and Performance Upgrades program. Phase 1 upgrades are designed to improve safety and performance that will enable the Space Shuttle to achieve the orbital inclination and altitude of the ISS. HEDS will also implement a variety of process improvements to enhance Shuttle safety and reliability and reduce costs. The performance targets will be to:

- Achieve seven or fewer flight anomalies per mission.

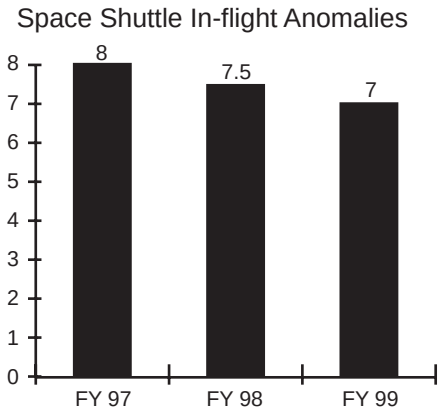


Figure 5

- Achieve 85-percent on-time, successful launches (excluding the risk of weather).

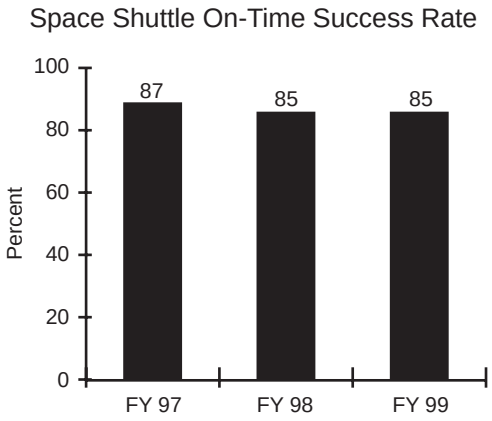


Figure 6

- Achieve a 13-month flight manifest preparation time.

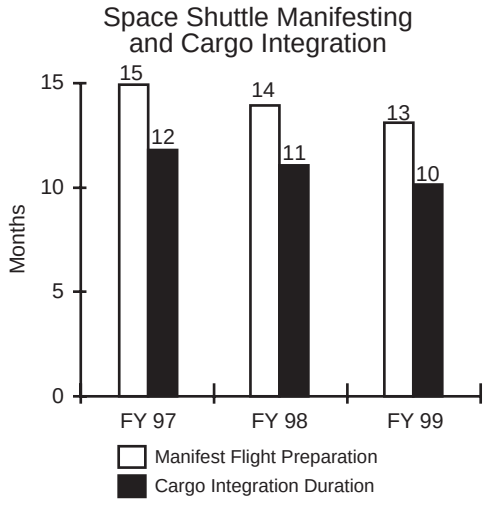


Figure 7

- Achieve a 60-percent increase in predicted reliability of the Space Shuttle over 1995.

Objective—Deploy and operate the ISS for research, engineering, and exploration activities

The ISS will provide the world with a permanent international research facility in low-Earth orbit. The facility will provide unprecedented space-based opportunities for the conduct of long-duration scientific research and technology demonstrations, as well as the capabilities for the commercial development of space. ISS laboratories will allow crews to learn to live and work in space and to demonstrate technologies for potential missions of human exploration beyond low-Earth orbit. The performance targets will be to:

- Deploy and activate the Russian-built FGB (Functional Cargo Block) as the early propulsion and cargo module.
- Deploy and activate the first U.S.-built element, Unity (Node 1), to provide docking locations and attach ports.
- Initiate full-scale Multi-Element Integration Testing (MEIT) for elements in the first four launch packages.
- Deliver the U.S. Laboratory Module to the launch site in preparation for MEIT.
- Conduct the physical integration of the Z1 Truss launch package and initiate MEIT.

Plans are under way to evaluate our ability to deploy payloads (such as human research, biotechnology, glovebox-type microgravity research) as early as possible during Phase II of the ISS. Lessons learned from Phase I will be incorporated into this process. Special attention will be given to foster the commercial activities. The performance targets will be to:

- Initiate preparations for the launch of the first EXPRESS rack with five payloads on Flight 7A-1.
- Initiate preparations for the launch of the first rack of the Human Research Facility (HRF-1) and the Window Observation Research Facility (WORF-1) on the first Utilization Flight (UF-1).

Objective—Ensure the health, safety, and performance of space flight crews

A consortium of seven universities has established the National Space Biomedical Research Institute to lead world-class space biomedical research to support HEDS. The Institute will undertake research on countermeasures and procedures to minimize the deleterious effects of space flight on the human body. The performance targets will be to:

- Complete the development of countermeasure research protocols and begin testing a minimum of three countermeasures intended to protect bone, muscle, and physical work capacity.
- Perform component and subsystem ground tests without humans in the loop to demonstrate advanced technologies, including the biological water processor, and flight-test a new electronic "nose" sensor on a chip.

Goal: Prepare to conduct human missions of exploration

Objective—In partnership with the Space Science Enterprise, carry out an integrated program of robotic exploration of the solar system to characterize the potential for human exploration and development

HEDS and the Space Science Enterprise will cooperate in developing mission objectives and technology requirements for robotic exploration of the solar system. This cooperation will help determine the feasibility and need for human missions of solar system exploration. In FY99, this collaboration will focus radiation and soil/dust research on robotic missions to Mars while evaluating options to

increase mission efficiency for both robotic and human missions, especially options to reduce launch mass. For example, calculations have shown that in-situ propellant production has the potential to significantly reduce (20 to 25 percent) launch mass requirements. Radiation hazards to human space flight in deep space have not been quantified. New combinations of materials, each possessing favorable performance-related characteristics (shielding, structural, and so on), may markedly improve synergistic possibilities for reduced launch mass.

Understanding and controlling flow and properties of particulates and granular materials have applications, from predicting rock slides and earthquakes to designing process operation for ores and polymer pellets. It is also important, for future exploration missions to the Moon and Mars, for developing protective measures against the ubiquitous Martian dust, ore benefaction, and handling of soil for in-situ resource utilization. The performance targets will be to:

- Initiate a collaborative program to design and develop radiation and soil/dust measuring devices.
- Plan for the demonstration of in-situ propellant production.

Objective—Explore and invest in enabling cross-cutting technology and studies that can affordably open up the frontiers for human space exploration where there is a compelling rationale for human involvement

HEDS will continue studying options for human exploration in support of the National Space Policy. This will be accomplished through a small cadre of Civil Service employees from NASA Field Centers, along with our partners from industry and other countries. Investments will be made in technologies to enable significant improvements in cost reduction, supportability, and operations of human missions. These technologies include propulsion, power, life support, communication, and navigation, and they will apply to the exploration of the Moon, Mars, and asteroids. A key element of these efforts will be the development of scientific partnerships and international cooperation. The performance targets will be to:

- Evaluate options and define the exploration technology investment plan.

Goal: Aggressively seek investment from the private sector, increase the affordability of space operations through privatization and commercialization, and share HEDS knowledge, technologies, and assets that promise to enhance the quality of life on Earth

Objective—Promote investments in commercial assets as pathfinders in ISS commercial operations and reduce the cost of Space Shuttle operations through privatization, eventual commercialization, and flying payloads

NASA is pursuing a capability to transfer the operation of the Space Shuttle and ISS to the private sector. The Space Flight Operations Contract is the initial focus of this objective. In a similar vein, the ISS program is developing processes and plans to facilitate commercial use and to highlight issues and advantages of commercial operations. The performance targets will be to:

- Complete the development of a commercialization plan for the ISS and Space Shuttle in partnership with the research and commercial investment communities, and define and recommend policy and legislative changes.

Objective—Reduce space communications and operations costs through privatization and eventual commercialization

HEDS is committed to the commercialization of operation services as directed in the National Space Policy. HEDS will also collaborate with other Strategic Enterprises, agencies, industries, and international partners to develop commercial initiatives. The performance targets will be to:

- Reduce space communications operations costs by 30 to 35 percent compared to the 1996 budget, through a consolidated space communications contract to meet established budget targets.
- Develop options and recommendations to commercialize space communications.

Objective—Foster consortia of industry, academia, and government; leverage funding, resources, and expertise to identify and develop commercial space opportunities

HEDS facilitates industry's use of space to develop competitive products that contribute to the Nation's economic growth. This program, which combines NASA and industry research and development capabilities, is implemented through the Commercial Space Centers (CSC) located throughout the country. CSC's are multidisciplinary consortia that work with industry, academia, and Government to facilitate the use of space for commercial products and services. Industry participation is an essential element of the program. Industry provides funding to pay for CSC-provided services, as well as in-kind industry personnel, equipment, and materials to facilitate commercial space research. The performance targets will be to:

- Increase non-NASA investment (cash and in-kind) in space research from $35 million in FY96 to at least $50 million in FY99—a 40-percent increase.
- Establish a new food technology CSC.

Objective—Involve our Nation's citizens in the adventure of exploring space and transfer knowledge and technologies to enhance the quality of life on Earth

HEDS will implement the ISS outreach and education plan, support NASA educational activities, maintain information pages on the Internet, and conduct annual ISS videoconferences for students and professional audiences. HEDS will contribute education and outreach support by developing appropriate curricula for National Science Teachers Association (NSTA), National Council of Teachers of Mathematics, and International Technology Education Association (ITEA) national conferences and assist in revisions of textbooks as appropriate. The performance targets will be to:

- Initiate a curriculum development program, in partnership with the ITEA, for gravity-related educational modules for national distribution that meet the current NSTA National Standards for Science for grades K–12 and the ITEA National Standards for Technology Education scheduled to be published in June 1999.
- Expand the microgravity research program's World Wide Web–based digital image archive established in 1998 by 50 percent.

HEDS research is directed toward maintaining the health and performance of space crews. Research into procedures and technologies to monitor health and provide care in remote and hostile environments is conducted. This research results in improved and efficient systems that can be easily adapted to Earth's environments. The performance targets will be to:

- Conduct at least two demonstrations of the applicability of the "Telemedicine Instrumentation Pack" for health care delivery to remote areas.
- Demonstrate the application of laser light scattering technology for the early detection of eye-

tissue damage from diabetes, and publish the results in peer-reviewed open literature.

External Assessment

The appropriate subcommittees of the NASA Advisory Council will conduct annual assessments of the progress made by the HEDS Enterprise in achieving its near-term performance targets. These committees will provide a qualitative progress measurement (Green, Yellow, or Red). “Green” will indicate that the target was met; “Yellow” will indicate a concern that a target was not fully accomplished; and “Red” will indicate that events occurred that prevented or severely impaired the accomplishment of the target. The assessment will include commentary to clarify and supplement the qualitative measures.

The following table provides a crosswalk between the 1998 NASA Strategic Plan and the HEDS FY99 performance goals. The goals and objectives of the HEDS Enterprise are under revision. The reader is directed to the text above for a full treatment of the current goals and objectives of the HEDS Enterprise.

Human Exploration and Development of Space Enterprise—Chart 5

HEDS Enterprise Strategic Goals	Objectives	Final FY 1999 Performance Targets	99#
Use the environment of space to expand scientific knowledge (OLMSA)	• Expand scientific knowledge by exploring the role of gravity and the space environment in physical, chemical, and biological processes through a vigorous peer-reviewed research program in space	• Support an expanded research program of approximately 800 investigations, an increase of about 9 percent over FY98.	H1
		• Publish 90 percent of FY98 science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make it available on the Internet.	H2
		• Publish a report of comparison of three different biological models to understand the influence of gravity on the nervous system.	H5
		• Publish a report defining the time course adaptions in the balance system to altered gravitational environments.	H6
		• Document *Mir* data lessons learned to facilitate ISS biomedical and countermeasure research.	H7
		• Document *Mir* data lessons learned to facilitate ISS research in fundamental biology and regenerative life support.	H8
		• Analyze *Mir* data to achieve 3-year jump-start for cell culture and protein crystal growth research, and document analyses and lessons learned.	H9
		• Document *Mir* radiation research data to facilitate ISS EVA planning.	H10
		• Improve predictive capabilities of soot processes by at least 50 percent through analysis of MSL-1 data, and publish the results in peer-reviewed open literature.	H11
		• Use MSL-1 results to eliminate one of the three primary fluid flow regimes from consideration by casting engineers for enhancing nucleation rate to form castings with a liner microstructure, and publish results in peer-reviewed literature.	H12
		• Use data obtained by fluid physics experiments on suspensions of colloidal particles on MSL-1 to answer fundamental questions in condensed matter physics regarding the transition between liquid and solid phases, and publish data on transition from liquids to solids and the results in peer-reviewed open literature.	H13
Provide safe and affordable human access to space, establish a human presence in space (Office of Space Flight)	• Improve Space Shuttle program operations by safely flying the manifest (scheduled missions) and aggressively pursuing a systems upgrade program that will reduce payload-to-orbit costs by a factor of 2 by 2002	• Achieve seven or fewer flight anomalies per mission.	H15
		• Achieve 85 percent on-time, successful launches (excluding weather risk).	H16
		• Achieve a 13-month manifest preparation time	H17
		• Achieve a 60-percent increase in predicted reliability of the Space Shuttle over 1995.	H18
	• Expand a permanent human presence in low-Earth orbit by transitioning from *Mir* to the ISS program to enhance and maximize science, technology, and commercial objectives	• Deploy and activate the Russian-built Functional Cargo Block (FGB) as the early propulsion and control module.	H19
		• Initiate preparations for the launch of the first EXPRESS rack with five payloads on assembly flight 7A-1.	H23
		• Initiate preparations for the launch of the Human Research Facility (HRF-1) and Window Observational Research Facility (WORF-1) on first utilization flight.	H24
		• Deploy and activate the first U.S.-built element, Unity (Node 1), to provide docking locations and attach ports.	H41
		• Initiate full-scale Multi-Element Integration Testing (MEIT) for elements in the first four launch packages.	H42
		• Deliver the U.S, Laboratory module to the launch site in preparation for MEIT.	H43
		• Conduct physical integration of the Z1 Truss launch package and initiate MEIT.	H44
	• Ensure the health, safety, and performance of space flight crews through cutting-edge medical practice using advanced technology	• Complete the development of countermeasure research protocols, and begin testing at least three countermeasures to protect bone, muscle, and physical work capacity.	H25
Prepare to conduct human missions of exploration to planetary and other bodies in the solar system (OLMSA and Office of Space Flight)	• With the Space Science Enterprise, carry out an integrated program of robotic exploration of Mars to characterize the potential for human exploration to support definition decision or human exploration as early as 2005	• Initiate a collaborative program to design and develop radiation and soil/dust measuring devices.	H26
		• Plan for the demonstration of in-situ propellant production.	H27

Human Exploration and Development of Space Enterprise—Chart 5 (continued)

HEDS Enterprise Strategic Goals	Objectives	Final FY 1999 Performance Targets	99#
Prepare to conduct human missions of exploration to planetary and other bodies in the solar system (continued)	• Establish the requirements and architecture for human exploration that can radically reduce cost through the use of local solar system resources, advanced propulsion technologies, commercial participation, and other advanced technologies	• Evaluate options and define the exploration technology investment plan. • Perform component and subsystem ground tests without humans in the loop to demonstrate advanced technologies, including the biological water processor, and flight-test a new electronic "nose" sensor on a chip.	H28 H29
Enable the commercial development of space and share HEDS knowledge, technologies, and assets that promise to enhance the quality of life on Earth (OLMSA)	• Transfer knowledge and technolgies, and promote partnerships to improve health and enhance the quality of life	• Establish a National Center for Evolutionary Biology with a minimum of five research institutions and 20 investigators.	H3
Provide safe and affordable human access to space, establish a human presence in space, and share the human experience of being in space (OLMSA and Office of Space Flight)	• Transfer knowledge and technolgies, and promote partnerships to improve health and enhance the quality of life	• Complete the development of a commercialization plan for the ISS and Space Shuttle in partnership with the research and commercial investment communities, and define and recommend policy and legislative changes. • Reduce space communications operations costs by 30–35 percent compared to 1996 budget, through a consolidated space communications contract to meet established budget targets. • Develop options and recommendations to commercialize space communications. • Increase industry investment (cash and in-kind) in space research from $35 million in FY96 to at least $50 million in FY99—a 40-percent increase.	H30 H33 H34 H35
Enable the commercial development of space and share HEDS knowledge, technologies, and assets that promise to enhance the quality of life on Earth (OLMSA)	• Transfer knowledge and technolgies, and promote partnerships to improve health and enhance the quality of life	• Establish a new food technology Commercial Space Center. • Initiate a curriculum development program, in partnership with the ITEA, for gravity-related educational modules for national distribution that meet NSTA standards for K–12 and the ITEA National Standards for Technology Education to be published in June 1999. • Expand the microgravity research program's web-based digital image archive established in 1998 by 50 percent. • Conduct at least two demonstrations of the applicability of the "Telemedicine Instrumentation Pack" for health care delivery to remote areas. • Demonstrate the application of laser light scattering technology for early detection of eye-tissue damage from Diabetes, and publish the results in peer-reviewed open literature.	H36 H37 H38 H39 H40

Human Exploration and Development of Space Budget Crosswalk—Chart 6

Strategic Objective / Budget Category	ISS	Space Flight Operations	Payload/ELV Support	Life and Microgravity	SOMO Mission Comm.	SOMO Space Comm.	R&PM	COF	Environmental	ETB	Technology Initiative	Education & Minority	SBIR	Performance Target Item # (Chart 3)	Other Objectives Addressed by Target (list)
Expand scientific knowledge by exploring the role of gravity and the space environment in phyusical, chemical, and biological processes through a vigorous peer-reviewed research program in space	Y	Y		X										H1, H7, H8, H9, H10	
				X										H2	
		Y		X										H5, H6, H11, H12, H13	
Improve Space Shuttle program operations by safely flying the manifest (scheduled missions) and aggressively pursuing a systems upgrade program that will reduce payload-to-orbit cots by a factor of 2 by 2002		X	Y											H15, H16, H17, H18	
Expand a permanent human presence in low-Earth orbit by transitioning from *Mir* to the ISS program to enhance and maximize science, technology, and commercial objectives	X	Y												H19, H23, H41, H42, H43, H44	
Ensure the health, safety, and performance of space flight crews through cutting-edge medical practice using advanced technology		Y		X										H25	
Note: X=Primary Contribution, Y=Secondary Contribution															

Human Exploration and Development of Space Budget Crosswalk—Chart 6 (continued)

Strategic Objective / Budget Category	ISS	Space Flight Operations	Payload/ELV Support	Life and Microgravity	SOMO Mission Comm.	SOMO Space Comm.	R&PM	COF	Environmental	ETB	Technology Initiative	Education & Minority	SBIR	Performance Target Item # (Chart 3)	Other Objectives Addressed by Target (list)
With the Space Science Enterprise, carry out integrated program of robotic exploration of Mars to characterize the potential for human exploration to support definition decision on human exploration as early as 2005														H26	
														H27	
Establish the requirements and architecture for human exploration that can radically reduce cost through the use of local solar system resources, advanced propulsion technolgies, commercial participation, and other advanced technologies														H28	
	Y	Y		X										H29	
Transfer knowledge and technologies, and promote partnerships to improve health and enhance the quality of life	Y	Y		X										H36	
	X	Y		Y										H30	
					X	X								H33, H34	
				X										H35, H37, H38, H39, H40	
				X										H3	

Note: X=Primary Contribution, Y=Secondary Contribution

Aero-Space Technology Enterprise

Mission

The Aero-Space Technology Enterprise mission is to pioneer the identification, development, verification, transfer, application, and commercialization of high-payoff aeronautics and space transportation technologies. The research and development programs conducted by the Enterprise contribute to national security, economic growth, and the competitiveness of American aerospace companies. The Enterprise plays a key role in maintaining a safe and efficient national aviation system and an affordable, reliable space transportation system. The Enterprise directly supports national policy in both aeronautics and space as directed in the President's Goals for a National Partnership in Aeronautics and Research Technology, the National Space Policy, and the National Space Transportation Policy.

Implementation Strategy

The Enterprise manages a clearly defined portfolio of technology investments to ensure alignment with national policy, Agency goals, customer requirements, and budget availability. The investment strategies are focused on issues associated with future aviation and space systems. Enterprise objectives are outcome focused and "stretch" beyond our current knowledge base. The outcome-focused nature of the objectives projects a preferred end-state within the air and space transportation systems. Designated Lead Centers have been assigned the responsibility to manage the implementation and execution phases of the technology programs. Enterprise programs are often conducted in cooperation with other Federal agencies, primarily the Federal Aviation Administration (FAA) and the Department of Defense. These partnerships take advantage of the national investment in aeronautics and astronautics capabilities and eliminate unnecessary duplication. The Enterprise supports the maturation of technology to a level that it can be confidently integrated into current and new systems. In most cases, technologies developed by the Enterprise can be directly transferred to the external customer.

Enterprise Resource Requirements

The President has requested the following budget for FY99 to FY03 to support the accomplishment of ASTT goals:

$M	FY 99	FY 00	FY 01	FY 02	FY 03
New Obligations Authority	1339	1092	1026	1057	1071
Civil Servants	4360	4342	4343	4313	4350

Performance Measures

To meet the near-term goals displayed in Figure 2 (page 7), the following objectives will be measured:

Objective—Contribute to aviation safety by reducing the aircraft accident rate

International attention has been focused on increasing our understanding and developing solutions to a severe icing condition that has been implicated in a number of commuter aircraft icing incidents, including fatal crashes. In FY99, NASA and Canada will collaborate to complete flight tests in severe weather conditions to build a data base on Super-cooled Large Droplets (SLD). This data base is important to understand severe icing factors in extreme cold temperatures. The FAA does not have this type of information for its current certification program. The NASA-Canadian initiative will provide the FAA with data for a new certification envelope. The performance target will be to:

- Characterize the SLD icing environment, determine its effects on aircraft performance, and acquire and publish data to improve SLD forecasting confidence.

More lives are lost to Controlled Flight Into Terrain (CFIT) than any other forms of commercial aviation accident. There has been a large number of headline examples. The typical CFIT accident scenario has no warning or indication of pilots perceiving any serious problems as they fly some segment of a landing approach. Distractions or disbelief of available information have been cited as primary factors for CFIT accidents. While human error will continue to be a factor in CFIT accidents, new technologies that help with low-visibility conditions (bad weather, the darkness of night, and/or fog) will provide pilots with vital, real-time data and images. These technologies will come in "packages" that are both cost effective and well suited for several market segments. In FY99 AST will select and evaluate technology concepts to eliminate CFIT accidents for both general aviation and transport category aircraft. The performance target will be to:

- Identify the contributing causes to be addressed, potential solutions using current capabilities, and gaps that require technology solutions for the aviation safety areas of CFIT, runway incursion, and loss of control.

Objective—Contribute to environmental compatibility by reducing aircraft emissions

Nitrogen oxides (NO_x) are a local air quality issue as well as a significant greenhouse gas. The aerosols and particulates from aircraft are also suspected of producing high-altitude clouds that could adversely affect Earth's climatology. Decisions have been made within the International Civil Aviation Organization (ICAO) to increase the stringency of the NO_x standard by adopting a 20-percent reduction from the current standard. The Committee on Aviation Environmental Protection is soliciting additional constraints to increase the NO_x stringency standard even further. Stringent NO_x limits could result in emissions fees or limited access to some countries, thereby adversely affecting U.S. airlines overseas operations. To address this challenge, NASA will work in partnership with industry and other Government agencies to ensure that safety and cost issues associated with the introduction of new technologies are understood prior to the establishment of new standards. Specifically, NASA is aggressively leading the way to demonstrate low-emission, environmentally acceptable, durable, safer, and cost-effective engine technologies that are required if airlines are to comply with international pressures to reduce aircraft engine emissions. The performance target will be to:

- Demonstrate an advanced turbine-engine combustor that will achieve up to a 50-percent reduction of NO_x emissions based on 1996 ICAO standards.

Objective—Advance high-speed travel by enabling the development of the High Speed Civil Transport

A complete vehicle system baseline, Technology Configuration, the second of three major High Speed Research (HSR) program milestones, will provide industry with a foundation to determine the technology requirements for the design and development of an environmentally compatible and economically competitive High Speed Civil Transport (HSCT). Studies indicate that over the next decade, the HSCT has the potential to result in 140,000 high-technology U.S. jobs and a $200 billion market. The performance target will be to:

- Produce a complete vehicle system configuration document that includes the impact of technology validation efforts from 1990 through 1999. This document will support the evaluation of technology selection decisions for a future HSCT.

Objective—Revitalize general aviation

Cost and reliability issues have contributed to the severe decline in the general aviation market. General aviation propulsion systems are a key element in reversing this trend. NASA formed a partnership with industry to develop and flight-demonstrate advanced propulsion systems for general aviation aircraft to address this issue. The cost-sharing partnership with Teledyne Continental Motors and Williams International is focused on the technology development of a new piston engine and a new turbofan engine that will reduce costs by 50 percent, increase the time between overhauls by 75 percent, and reduce specific fuel consumption by 25 percent. Together, these technologies will significantly improve the performance and reduce the operational cost of general aviation aircraft. The performance target will be to:

- Conclude preflight ground testing of the general aviation piston and turbofan engines.

Objective—Develop next-generation experimental aircraft

The Aero-Space Technology Enterprise's Industry/Government/University Environmental Research Aircraft and Sensor Technology (ERAST) Alliance will support future Earth Science Enterprise activities in which in-situ data collection is required to complement (with greater resolution) and calibrate satellite observations. The Alliance transfers new technology to U.S. industry to create new civil capability for commercial and scientific applications. The performance targets will be to:

- Complete low-altitude flights of an Remotely Piloted Aircraft (RPA) with a wingspan greater than 200 feet, suitable for flight to 100,000 feet in altitude once outfitted with high-performance solar cells.
- Conduct RPA flight demonstrations to validate the capability for science missions of greater than 4 hours duration in remote deployments to areas such as the polar regions above 55,000 feet.

Objective—Develop next-generation design tools

NASA continues to advance its High Performance Computing and Communications (HPCC) networking capabilities as part of the Federal HPCC program. The Aero-Space Technology Enterprise's work on the Next Generation Internet will also improve network communications for the researchers of all disciplines. Benefits from this program include new computational advances such as this project, as well as capabilities in aeronautics, space transportation, Earth science, space science, and educational outreach. The performance targets will be to:

- Demonstrate up to a 200-fold improvement over the 1992 baseline (reduce from 3,200 hours to 15) in the time-to-solution for a full combustor simulation on NASA's National Propulsion System Simulation advanced applications on computational testbeds that can be increased to sustained TeraFLOPS capability.
- Demonstrate communication testbeds with up to a 500-fold improvement over the 1996 baseline (increase from 300 kilobits per second to 150 megabits per second) in end-to-end performance.

Objective—Revolutionize space launch capabilities

The X-33 is an integrated technology effort to flight-demonstrate key technologies and deliver advancements in:

1. Ground and flight operations techniques that will substantially reduce operations costs for an Reusable Launch Vehicle (RLV)

2. Lighter, reusable cryogenic tanks
3. Lightweight, low-cost composite structures
4. Advanced thermal protection systems to reduce maintenance
5. Propulsion and vehicle integration
6. Application of New Millennium microelectronics for vastly improved reliability and vehicle health management

With flight tests beginning in FY 2000 and to be completed near the end of calendar year 2000, the X-33 program will demonstrate technologies that are traceable to the mass fraction (less than 10 percent empty vehicle weight) required for future RLV's and will meet the following operational requirements: validation of key aerothermodynamic environments to reduce uncertainty of predictive models for thermal protection system requirements; flights faster than Mach 13; 48-hour and 7-day ground turnarounds; and small maintenance crews (about 50 persons). The flight test results will be combined with the successes of the DC-XA, X-34, and complementary ground technology advances. The combined results will reduce the technical risk of full-scale development of an operational RLV. The performance target will be to:

- Continue the X-33 vehicle assembly in preparation for flight-testing.

The X-34 program will demonstrate technologies necessary for a reusable vehicle, but will not be a commercially viable vehicle itself. The X-34 will be a rocket-powered, Mach-8-capable flight demonstrator testbed to close the performance gap between the subsonic DC-XA and the Mach 13 X-33. The X-34 objective is to enhance U.S. commercial space launch competitiveness through the development and demonstration of key technologies applicable to future, low-cost RLV's. The X-34 will demonstrate flexible integration capability, high flight rate (up to 25 flights per year), autonomous flight operations, safe abort capability, landing in cross winds up to 20 knots, flights through rain and fog, and a recurring flight cost of $500,000 or less. The performance target will be to:

- Complete vehicle assembly and begin flight-testing of the X-34.

Objective—Provide world-class aerospace research and development services, facilities, and expertise

The Aero-Space Technology Enterprise's Field Centers provide American industry and academic personnel with world-class research facilities, such as wind tunnels and advanced computational devices. The Enterprise conducts an exit interview to determine the degree of satisfaction customers feel that they received by using NASA facilities. The performance targets will be to:

- Complete 90 percent of Enterprise-controlled milestones within 3 months of schedule.

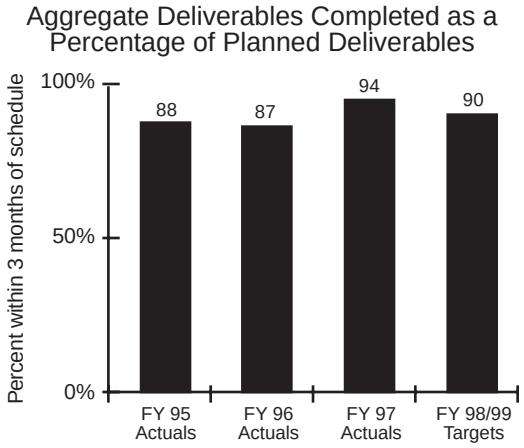


Figure 8

- Achieve a facility utilization customer satisfaction rating of 95 percent of respondents at "5" or better and 80 percent at "8" or better based on exit interviews.

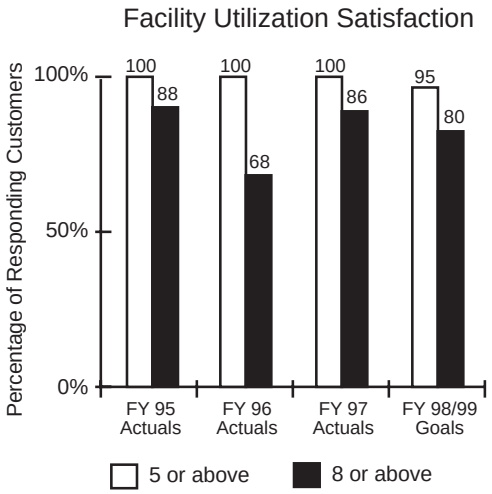


Figure 9

- Complete the Triennial Customer Satisfaction Survey, and achieve an improvement from 30 percent to 35 percent in "highly satisfied" ratings from Enterprise customers.

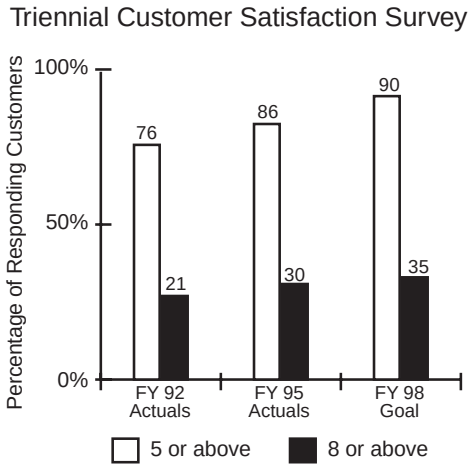


Figure 10

- Transfer at least 10 new technologies and processes to industry during the fiscal year.

The Enterprise's research and technology programs provide important contributions to education and the public's understanding of air and space transportation. Providing a steady return of discoveries and new knowledge contributes to the accomplishment of this objective. The Enterprise will continue its outreach and education activities through several venues. The Enterprise uses a Mobile Aeronautics Education Laboratory to demonstrate technology applications for education. This mobile trailer is equipped with lesson plans and software that are used at schools, conferences, and aeronautics research centers. The Enterprise also makes extensive use of the Internet to share educational material in the areas of science, mathematics, and technology with teachers and students. The performance targets will be to:

- Establish an Aeronautics Education Laboratory in at least three new sites in the United States.
- For all new program activities initiated in FY99, develop an education outreach plan, which includes and results in an educational product. This product shall be consistent with current educational standards and use program content to demonstrate or enhance the learning objectives.

External Assessment

The Aeronautics and Space Transportation Technology Committee of the NASA Advisory Council will conduct annual assessments of the progress made by the Aero-Space Technology Enterprise in achieving its near-term technology objectives. This committee will provide a qualitative progress measurement (Green, Yellow, or Red). "Green" will indicate that the objective was met; "Yellow" will indicate a concern that an objective was not fully accomplished; and "Red" will indicate that events occurred that prevented or severely impaired the accomplishment of the objective. The assessment will include commentary to clarify and supplement the qualitative measures.

Aero-Space Technology Enterprise—Chart 7

Aero-Space Technology Enterprise Strategic Goals	Objectives	Final FY 1999 Performance Targets	99#
Global Aviation—Enable U.S. leadership in global civil aviation through safer, cleaner, quieter, and more affordable air travel	• Contribute to aviation safety by reducing the aircraft accident rate	• Characterize the Super-cooled Large Droplets (SLD) icing environment, determine its effects on aircraft performance, and acquire and publish data to improve SLD forecasting confidence	R2
		• For the aviation safety areas of Controlled Flight Into Terrain, runway incursion, and loss of control, identify the contributing causes to be addressed, potential solutions using current capabilities, and gaps that require technology solutions.	R5
	• Contribute to environmental compatibility by reducing aircraft emissions	• Demonstrate an advanced turbine-engine combustor that will achieve up to a 50-percent reduction of NO_x emissions based on 1996 ICAO standards.	R1
Revolutionary Technology Leaps—Revolutionize air travel and the way in which aircraft are designed, built, and operated	• Advance high-speed travel by enabling the development of the HSCT	• Produce a complete vehicle system configuration document that includes impact of technology validation efforts from 1990 through 1999. This document will support the evaluation of technology selection decisions for a future HSCT.	R6
	• Revitalize general aviation	• Conclude preflight ground testing of the general aviation piston and turbofan engines.	R8
	• Develop next-generation experimental aircraft	• Complete low-altitude flights of an RPA with a wingspan greater than 200 feet, suitable for flight to 100,000 feet in altitude once outfitted with high-performance solar cells.	R10
		• Conduct RPA flight demonstrations to validate the capability for science missions of greater than 4 hours duration in remote deployments to areas such as the polar regions above 55,000 feet.	R11
	• Develop next-generation computational design tools	• Demonstrate communication testbeds with up to 500-fold improvement over the 1996 baseline (increase from 300 kilobits per second to 150 megabits per second) in end-to-end performance.	R13
	• Develop next-generation design tools	• Demonstrate up to a 200-fold improvement over the 1992 baseline (reduction from 3,200 hours to 15) in the time-to-solution for a full combustor simulation on NASA's National Propulsion System Simulation advanced applications on computational testbeds that can be increased to sustained TeraFLOPS capability.	R12
Access to Space—Enable the full commercial potential of space and expansion of space research and exploration	• Revolutionize space launch capabilities	• Continue the X-33 vehicle assembly in preparation for flight-testing.	R14
		• Complete vehicle assembly and begin flight-testing of the X-34.	R15
Research and Development (R&D)—Enable, as appropriate, on a national basis, world-class aerospace R&D services, including facilities and expertise, and proactively transfer cutting-edge technologies in support of industry and U.S. Government R&D	• Provide world-class aerospace research and development services, facilities, and expertise	• Complete 90 percent of all Enterprise-controlled milestones within 3 months of schedule	R16
		• Achieve a facility utilization customer satisfaction rating of 95 percent of respondents at "5" or better and 80 percent at "8" or better based on exit interviews.	R17
		• Complete the Triennial Customer Satisfaction Survey, and achieve an improvement from 30 percent to 35 percent in "highly satisfied" ratings from Enterprise customers.	R18
		• Transfer at least 10 new technologies and processes to industry during the fiscal year.	R19
		• Establish an Aeronautics Education Laboratory in at least three new sites in the United States.	R20
		• For all new program activities initiated in FY99, develop an education outreach plan, which includes and results in an educational product that is consistent with current educational standards and uses program content to demonstrate or enhance the learning objectives.	R21

Aero-Space Technology Budget Crosswalk—Chart 8

Strategic Objective / Budget Category	AST/Flight Demo	High Speed Research	Adv. Subsonics Technology	Aviation Systems Capacity	HPCC	Adv. Space Transportation Technology	Aeronautics R&T	Commercial Technology	R&PM	COF	Environmental	Education & Minority	SBIR	Performance Target Item # (Chart 4)	Other Objectives Addressed by Target (list)
Safety—reduce aircraft accident rate							X		X					R2, R5	
Environmental compatibility—reduce emissions			X						X					R1	
High-speed travel—enable development of HSCT		X							X					R6	
Revitalize general aviation			X						X					R8	
Develop next-generation experimental aircraft							X		X					R10, R11	
Develop next-generation design tools					X				X					R12, R13	
Revolutionize space launch capabilities	X								X					R14, R15	
Provide world-class aerospace research and development services, facilities, and expertise	X	X	X	X	X	X	X		X					R16*, R18, R19	
							X		X					R17	
							X		X					R20, R21	

Note: X=Primary Contribution, Y=Secondary Contribution

* Note on R16: All program milestones contribute to meeting this target.

Manage Strategically

Goal

This Process coordinates the Strategic Management System by which the Agency develops the plans, implementation strategies, and evaluation processes to achieve NASA's goals. This Process provides policy direction and implementation guidelines to NASA's organizational elements and employees as they develop, conduct, and evaluate programs central to the Agency's vision. The goal of this Process is to ensure that the Agency carries out its responsibilities effectively and safely and that management makes critical decisions regarding implementation activities and resource allocations that support NASA's strategic, implementation, and performance plans.

NASA seeks to carry out its functional management responsibilities in ways that strengthen the Agency's ability to meet the goals of its Strategic Enterprises, as well as support the priorities of Congress and the President. For FY99, NASA's strategic management performance objectives (and associated performance targets) require us to make the most effective use of the abilities of our "downsized" workforce, as well as our appropriated funds, procurement processes, and information technologies.

Performance Measures

To meet the near-term goals displayed in Figure 2 (page 7), the following objectives will be measured:

Objective—Optimize investment strategies and systems to align human, physical, and financial resources with customer requirements, while ensuring compliance with applicable statutes and regulations

The National Performance Review established a Governmentwide goal to reduce the size of the Federal workforce to the level of 1960. The performance targets for functions related to human resources will be to:

- Reduce the Civil Service workforce level to below 19,000.

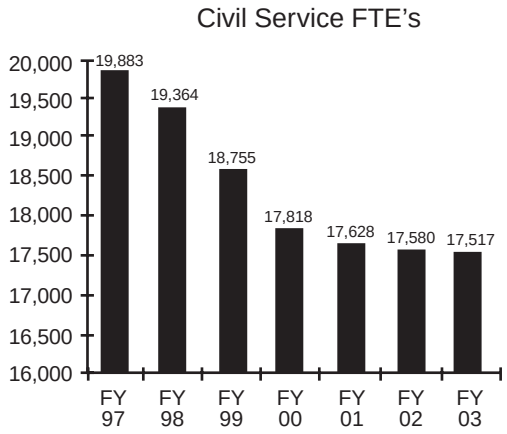


Figure 11

- Maintain a diverse NASA workforce through the downsizing efforts (see Figure 13 on page 46).
- Reduce the number of Agency lost workdays (from occupational injury or illness to NASA personnel) by 5 percent from the FY94–96 3-year average.

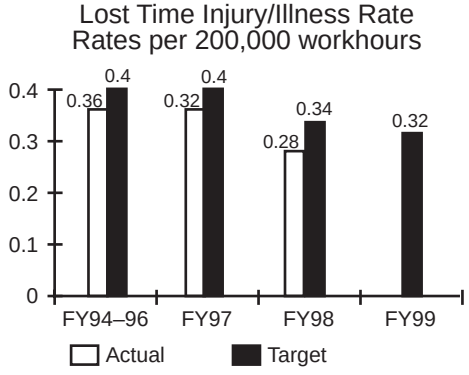


Figure 12

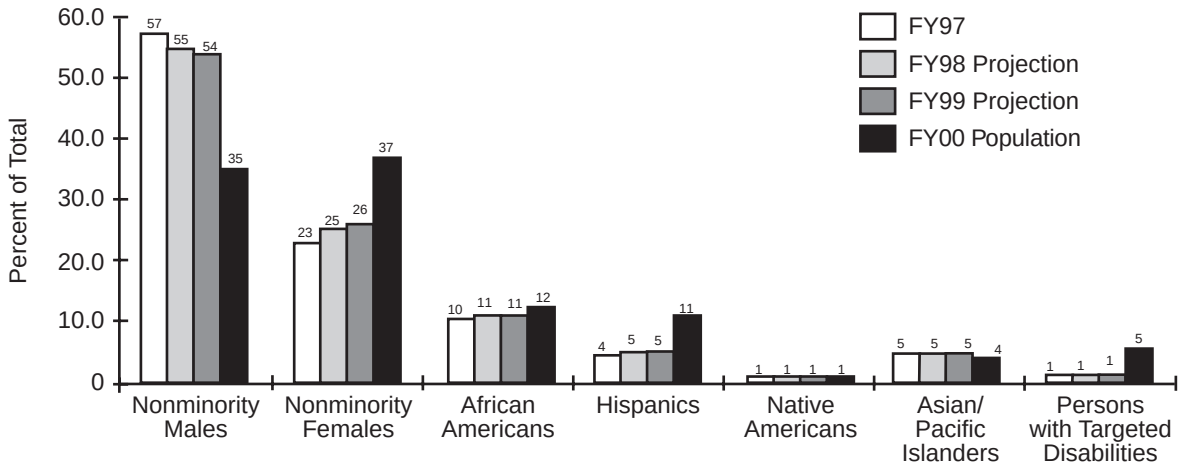


Figure 13

Functional and staff offices maintain the capabilities to improve the effectiveness and efficiency of Agency management systems that contribute to the "faster, better, cheaper" approach. The performance targets will be to:

- Achieve a 5-percent increase in physical resource costs avoided from the previous year through alternative investment strategies (for example, dollars avoided through increased energy conservation, recycling, pollution prevention, and facilities maintenance inspection initiatives across the Agency).

Cost Avoided Through Alternative Investment Strategies

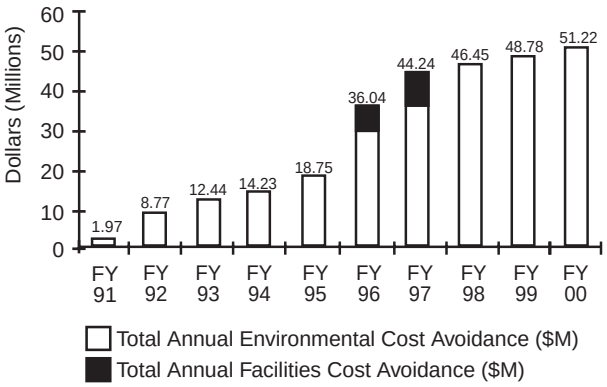


Figure 14

- Achieve 70 percent or more of the resources authority available to cost within the fiscal year.

Percentage of Available Resources Authority Costed

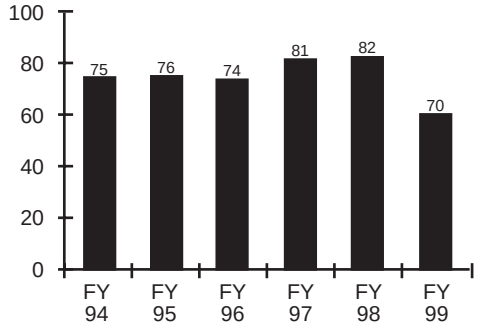


Figure 15

- Implement new financial systems and business procedures (including a new financial classification structure and full cost budgeting and accounting procedures) through the introduction and installation of the Integrated Financial Management Program (IFMP). System validation will take place in FY99, and systems installation will be accomplished at the Marshall Space Flight Center and the Dryden Flight Research Center.

Objective—Improve effectiveness and efficiency of Agency acquisitions through increased use of techniques and management that enhance contractor innovations and performance

The performance targets will be to:

- Increase performance based contract (PBC) obligations to 80 percent of funds available for PBC's. ("Funds available" exclude grants, cooperative agreements, procurement actions involving amounts less than $100,000, Federally Funded Research and Development Centers, the Small Business Innovation Research and Small Business Technology Transfer programs, intragovernmental agreements, and contracts with foreign governments or international organizations.)

NASA PBC Obligations as Percents of Funds Available for PBC

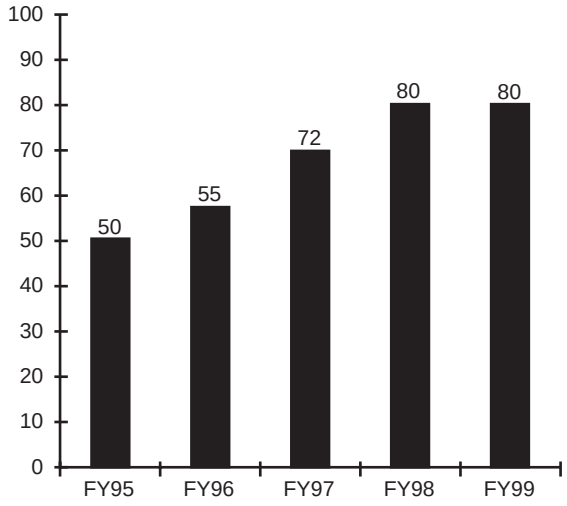


Figure 16

- Enhance contract management through improved systems and information for monitoring and through an emphasis on the training of procurement personnel, and revise metrics to assess the overall health of the procurement function. A strategy for evaluating the efficacy of procurement operations will be implemented in FY99.
- Achieve at least the congressionally mandated 8-percent goal for annual funding to small disadvantaged businesses. This includes funding for prime and subcontracts awarded in support of authorized programs. Included in this measurement are small disadvantaged businesses, Historically Black Colleges and Universities, other minority institutions, and women-owned small businesses.

Funding to Small Disadvantaged Businesses
(% of Agency Funding)

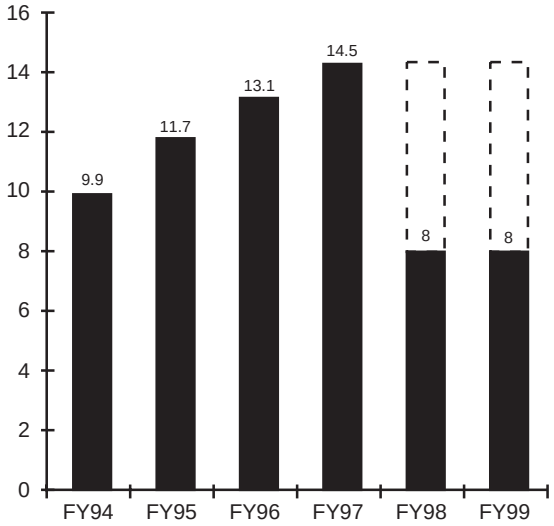


Figure 17

Objective—Ensure that information technology provides an open and secure exchange of information, is consistent with Agency technical architectures and standards, demonstrates a projected return on investment, reduces risk, and directly contributes to mission success

The performance target will be to:

- Improve information technology infrastructure service delivery to provide increased capability and efficiency while maintaining both a customer rating of "satisfactory" and costs per resource unit at the FY98 baseline.
- Complete the remediation of mission-critical systems by March 1999, consistent with Governmentwide guidelines for Year 2000.

Manage Strategically Process—Chart 9

Manage Strategically Goal	Objectives	Final FY 1999 Performance Targets	99#
Provide a basis for the Agency to carry out its responsibilities effectively and safely and enable management to make critical decisions regarding implementation activities and resource allocations that are consistent with the goals, objectives, and strategies contained in NASA's Strategic, Implementation, and Performance Plans	• Optimize investment strategies and systems to align human, physical, and financial resources with customer requirements, while ensuring compliance with applicable statutes and regulations	• Reduce the Civil Service workforce level to below 19,000.	MS1
		• Maintain a diverse NASA workforce through the downsizing efforts.	MS2
		• Reduce the number of Agency lost workdays (from occupational injury or illness) by 5 percent from the FY94–96 3-year average.	MS3
		• Achieve a 5-percent increase in physical resource costs avoided through alternate investment strategies in environmental and facilities operations.	MS4
		• Achieve 70 percent or more of the resources authority available to cost within the fiscal year.	MS5
		• Complete system validation of the Integrated Financial Management Program, and complete system implementation at Marshall and Dryden.	MS12
	• Improve effectiveness and efficiency of Agency acquisitions through increased use of techniques and management that enhance contractor innovations and performance	• Increase obligated funds available for performance based contracts (PBC) to 80 percent (funds available exclude grants, cooperative agreements, actions <$100,000, SBIR, STTR, FFRDC's, intragovernmental agreements, and contracts with foreign governments or international organizations).	MS6
		• Achieve at least the congressionally mandated 8-percent goal for annual funding to small disadvantaged businesses (including prime and subcontracts, small disadvantaged businesses, HBCU's, other minority institutions, and women-owned small businesses).	MS7
		• Enhance contract management through improved systems and information for monitoring and through an emphasis on the training of procurement personnel, and revise metrics to assess the overall health of the procurement function.	MS9
		• Enhance contract management through improved systems and information for monitoring and through an emphasis on the training of procurement personnel, and implement a strategy for evaluating the efficacy of procurement operations.	MS10
	• Improve information technology capability and services	• Improve information technology infrastructure service delivery to provide increased capability and efficiency while maintaining both a customer rating of "satisfactory" and costs per resource unit at the FY98 baseline.	MS8
		• Complete the remediation of mission-critical systems by March 1999, consistent with Governmentwide guidelines for Year 2000.	MS11

* Performance targets address Agency action related to major management challenges (GAO/NSIAD/98-181, dated June 5, 1998).

Manage Strategically FY 1999 Budget Crosswalk—Chart 10

Strategic Objective / Budget Category	HEDS	Aero-Space Technology	Space Science	Earth Science	R&PM	Safety & Mission Assurance	COF	Environmental	Education & Minority	Performance Target Item # (Chart 5)	Other Objectives Addressed by Target (list)
Optimize investment strategies and systems to align human, physical, and financial resources with customer requirements, while ensuring compliance with applicable statutes and regulations	X	X	X	X	X					MS1, MS2, MS4, MS5, MS12	
					X					MS2	
					X	X				MS3	
					X		X	X		MS4	
Improve effectiveness and efficiency of Agency acquisitions through increased use of techniques and management that enhance contractor innovations and performance					X					MS9, MS10	
	X	X	X	X	X					MS6, MS7	
Improve information technology capability and services					X					MS8	
	X	X	X	X	X					MS11	
Note: X=Primary Contribution, Y=Secondary Contribution											

Provide Aerospace Products and Capabilities

Goal

This Process is the means by which NASA's Strategic Enterprises and their Centers deliver systems (ground, aeronautics, and space), technologies, data, and operational services to NASA customers. Through the use of Agency facilities, customers can conduct research, explore and develop space, and improve life on Earth. This Process is used to answer the Agency's fundamental question: "What cutting-edge technologies, processes, techniques, and engineering capabilities must we develop to implement our research agenda in the most productive, economical, and timely manner?" The goal of the Process is to enable NASA's Strategic Enterprises and their Centers to deliver products and services to customers more effectively and efficiently. The Process is also used to extend broadly the technology, research, and science benefits from NASA programs to the public and to commercial sectors.

Performance Measures

To meet the near-term goals displayed in Figure 2 (page 7), the following objectives will be measured:

Objective—Reduce the cost and development time to deliver products and operational services

NASA's role in the advancement of research and technology is conducted through the construction and operation of facilities such as telescopes, satellites, and ground-based laboratories and test facilities. Meeting cost and schedule commitments is critical. The first performance target will be to:

- Meet schedule and cost commitments by keeping the development and upgrade of major scientific facilities and capital assets within 110 percent of cost and schedule estimates, on average.

In addition, the "faster, better, cheaper" approach attempts to reduce spacecraft development time and costs while continuing to improve performance. Performance targets in this area will be to:

- Reduce the 5-year average spacecraft cost for Space Science and Earth Science missions to $200 million from $590 million.

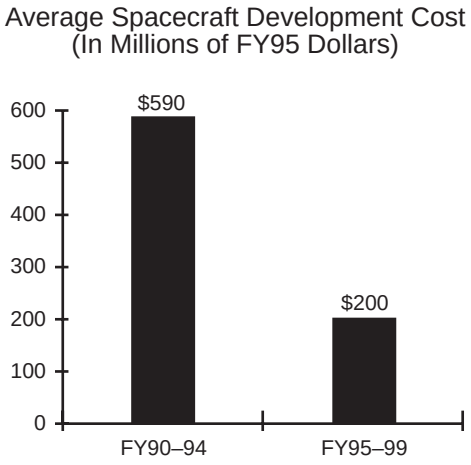


Figure 18

- Reduce the 5-year average spacecraft development time for Space Science and Earth Science to 5 years, 2 months from 8 years, 3 months.

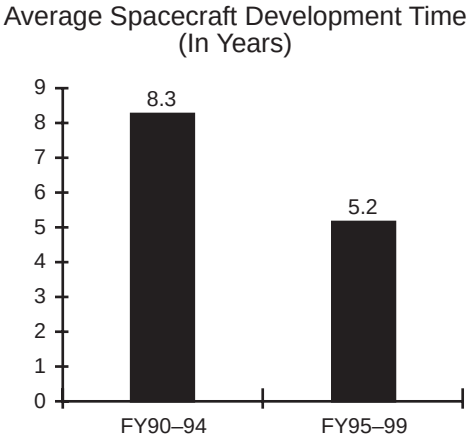


Figure 19

Objective—Improve and maintain NASA's engineering capability

The performance targets will be to:

- Set up a process to determine, on average, the operating time of NASA's spacecraft and ground facilities lost to unscheduled downtime, and establish a baseline in FY99.
- Set up a process to improve engineering skills and tools within the Agency.

Objective—Capture and preserve engineering and technological best practices and process knowledge to continuously improve NASA's program/project management

The performance target will be to:

- Set up a process in FY99 to capture a set of best practices/lessons learned from each program, including at least one from each of the four Provide Aerospace Products and Capabilities subprocesses, commensurate with current program status.

Objective—Focus on integrated technology planning and development in cooperation with commercial industry and other NASA partners and customers

Technologies are some of the key enabling products provided through the Provide Aerospace Products and Capabilities Process. Leveraging NASA technology activities with those of other organizations vastly increases the total value of such activities. The performance targets will be to:

- Set up a data collection process to determine the amount of leveraging of the R&D budget with the activities of other organizations, and establish a baseline in FY99.
- Set up a process to determine percentage of the Agency's R&D budget dedicated to commercial partnerships, and establish a baseline.

Provide Aerospace Products and Capabilities Process—Chart 11

Provide Aerospace Products and Capabilities Goal	Objectives	Final FY 1999 Performance Targets	99#
Enable NASA's Strategic Enterprises and their Centers to deliver products and services to customers more effectively and efficiently while extending the technology, research, and science benefits broadly to the public and commercial sectors	• Reduce the cost and development time to deliver products and operational services	• Meet schedule and cost commitments by keeping the development and upgrade of major scientific facilities and capital assets within 110 percent of cost and schedule estimates, on average. • Reduce the 5-year average spacecraft cost for Space Science and Earth Science missions to $200 million from $590 million.	P1 P3
	• Reduce mission cost and development time to deliver high quality products	• Reduce the 5-year average spacecraft development time for Space Science and Earth Science to 5 years, 2 months from 8 years, 3 months.	P4
	• Improve and maintain NASA's engineering capability	• Set up a process to determine, on average, the operating time of NASA's spacecraft and ground facilities lost to unscheduled downtime, and establish a baseline in FY99. • Set up a process to improve engineering skills and tools within the Agency.	P2 P8
	• Capture and preserve engineering and technological best practices and process knowledge to continuously improve NASA's program/project management	• Set up a process in FY99 to capture a set of best practices/lessons learned from each program, including at least one from each of the four Provide Aerospace Products and Capabilities subprocesses, commensurate with current program status.	P5
	• Focus on integrated technology planning and technology development in cooperation with commercial industry and other NASA partners and customers	• Set up a process to determine percentage of the Agency's R&D budget dedicated to commercial partnerships, and establish a baseline. • Set up a data collection process to determine the amount of leveraging of the R&D budget with the activities of other organizations, and establish a baseline in FY99.	P6 P7

Provide Aerospace Products and Capabilities FY 1999 Budget Crosswalk—Chart 12

Strategic Objective / Budget Category	HEDS	Aero-Space Technology	Space Science	Earth Science	R&PM	Safety & Mission Assurance	COF	Environmental	Education & Minority	Performance Target Item # (Chart 6)
Reduce mission cost and development time to deliver products and operational services	X	X	X	X						P1, P3, P4
Improve and maintain NASA's engineering capability	X	X	X	X						P2, P8
Capture and preserve engineering and technological best practices and process knowledge to continuously improve NASA's program/project management	X	X	X	X						P5
Focus on integrated technology planning and technology development in cooperation with commercial industry and other NASA partners and customers	X	X	X	X						P6, P7
Note: X=Primary Contribution, Y=Secondary Contribution										

Generate Knowledge

Goal

NASA provides new scientific and technological knowledge gained from exploring Earth, the solar system, and the universe and from conducting aeronautics and astronautics research and development. This Process ensures that this information is shared with scientists, engineers, and technologists in industry, academia, and other organizations. In addition, natural resource managers, policymakers, and educators benefit from this Process, which plays a major role in seeking answers to the fundamental questions of science and research. The goals of the Generate Knowledge Process are to extend the boundaries of knowledge of science and engineering, to capture new knowledge in useful and transferable media, and to share new knowledge with customers.

Performance Measures

To meet the near-term goals displayed in Figure 2 (page 7), the following objectives will be measured:

Objective—Select research projects through peer-reviewed and merit-based competition

The performance target will be to:

- Submit 80 percent of Agency research projects to peer-reviewed processes. Proposals submitted to NASA for funding will be selected through a merit-based competitive process.

Objective—Provide information to the public and data to researchers

The performance target for prompt public information will be to:

- Provide monthly updates for all missions and, when possible, on a weekly basis.

The performance target to validate science data will be to:

- Make available for researchers fully calibrated, verified, and validated science data products within 1 year of acquisition.

Generate Knowledge Process—Chart 13

Generate Knowledge Goal	Objectives	Final FY 1999 Performance Targets	99#
Extend the boundaries of knowledge of science and engineering, capture new knowledge in useful and transferable media, and share new knowledge with customers	• Select research projects through peer-reviewed and merit-based competition	• Submit 80 percent of Agency research projects to peer-reviewed processes.	GK1
	• Provide information to the public and data to researchers	• Provide monthly updates for all missions and, when possible, on a weekly basis. • Make available for researchers fully calibrated, verified, and validated science data products within 1 year of acquisition.	GK2 GK3

Generate Knowledge FY 1999 Budget Crosswalk—Chart 14

Strategic Objective / Budget Category	HEDS	Aero-Space Technology	Space Science	Earth Science	R&PM	Safety & Mission Assurance	COF	Environmental	Education & Minority	Performance Target Item # (Chart 7)	Other Objectives addressed by Target (list)
Select research projects through peer-reviewed and merit-based competition	X		X	X	X					GK1	
Provide information to the public and data to researchers	X	X	X	X	X					GK2, GK3	
Note: X=Primary Contribution, Y=Secondary Contribution											

Communicate Knowledge

Goal

The Communicate Knowledge Process facilitates the distribution of information on NASA's missions and discoveries. This supports the increased understanding of science and technology, promotes the application of NASA-generated information, and inspires achievement and innovation. The Process ensures that knowledge derived from the NASA research programs is available to meet the specific needs and interests of constituent groups. This Process begins with the inception of a research project and increases in intensity as the effort reaches maturity to ensure the appropriate delivery, archiving, and future convenient access of all research results. The goal of the Communicate Knowledge Process is to ensure that information derived from NASA's research efforts is distributed in a useful, timely, and reliable manner.

Performance Measures

To meet the near-term goals displayed in Chart 2 (page 7), the following objectives will be measured:

Objective—Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA's programs

NASA will produce communications metrics for the four NASA Enterprises for (1) scientific and technical information, (2) public affairs, (3) education, (4) history, and (5) technology transfer. The scientific and technical information target will be to:

- Acquire 10,550 NASA-sponsored, -funded, and/or -generated report documents for the American scientific community and public, publish 26 issues of an electronic current awareness product to announce additions to the NASA scientific and technical information data base, and add 24,400 bibliographic/citation records to the online NASA scientific and technical information data base describing scientific and technical publications available to the American public.

The history targets will be to:

- Produce 10 new publications chronicling and placing NASA's activities and achievements in perspective for the American public.
- Sponsor or cosponsor one major scholarly conference.

Objective—Highlight existing and identify new opportunities for NASA's customers, including the public, the academic community, and the Nation's students, to directly participate in space research and discovery

The education targets will be to:

- Increase the number of educators who participate annually in NEWEST/NEWMAST to 500 from 400 in FY98.

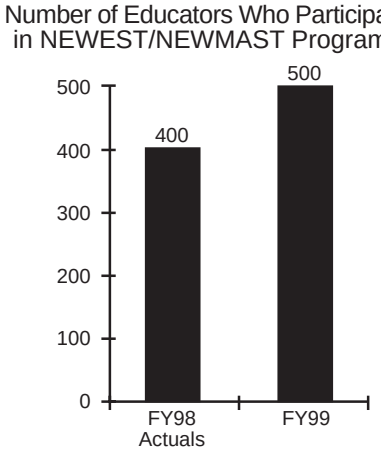


Figure 20

- Increase the number of students reached through the program to 42,000 students from 33,600 in FY98.

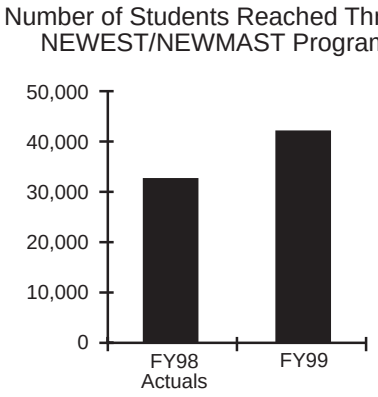


Figure 21

- Maintain the participation level in Agencywide educational programs at more than 1 million teachers and students.

The technology transfer target will be to:

- Increase new technology opportunities from 19,600 to 19,700. These will be made available to the public through the TechTracs data base and will be measured by monitoring a controlled data field that indicates the number of new technologies communicated to the public.

Communicate Knowledge Process—Chart 15

Communicate Knowledge Goal	Objectives	Final FY 1999 Performance Targets	99#
Ensure that NASA's customers receive the information derived from NASA's research efforts that they want, in the format they want, for as long as they want it	• Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA's programs	• Produce 10 new historical publications chronicling and placing NASA's activities and achievements in perspective for the American public, and sponsor or cosponsor one major scholarly conference.	CK9
		• Acquire 10,550 NASA-sponsored, -funded, and/or -generated report documents for the American scientific community and public, publish 26 issues of an electronic current awareness product to announce additions to the NASA science and technical information data base, and add 24,400 bibliographic/citation records to the online NASA science and technical information data base.	CK10
	• Highlight existing and identify new opportunities for NASA's customers, including the public, the academic community, and the Nation's students, to directly participate in space research and discovery	• Increase the number of educators who participate annually in NEWEST/NEWMAST to 500 from 400 in FY98.	CK1
		• Increase the number of students reached through the NEWEST/NEWMAST program to 42,000 students from 33,600 in FY98.	CK2
		• Maintain the participation level in Agencywide educational programs at more than 1 million teachers and students.	CK3
		• Increase new technology opportunities from 19,600 to 19,700. These will be made available to the public through the TechTracs database and will be measured by monitoring a controlled data field that indicates the number of new technologies communicated to the public.	CK12

Communicate Knowledge FY 1999 Budget Crosswalk—Chart 16

Strategic Objective / Budget Category	HEDS	Aero-Space Technology	Space Science	Earth Science	R&PM	Safety & Mission Assurance	COF	Environmental	Education & Minority	Performance Target Item # (Chart 8)	Other Objectives Addressed by Target (list)
Improve the external constituent communities' knowledge, understanding, and use of results and opportunities associated with NASA's programs	Y	Y	Y	Y	X					CK9, CK10	
Highlight existing and identify new opportunities for NASA's customers, including the public, the academic community, and the Nation's students, to participate directly in space and research discovery	Y	X	Y	Y	X				X	CK1, CK2, CK3, CK12	

Note: X=Primary Contribution, Y=Secondary Contribution

Performance Evaluation

Performance will be evaluated by internal and external processes. Agency management councils will conduct internal reviews, as described in the NASA Strategic Management Handbook. Throughout the year, Program Management Councils at Headquarters and the Centers will assess program schedules, cost, and technical performance against established programmatic commitments. With membership of Headquarters Officials-in-Charge and Center Directors, the Senior Management Council will conduct assessment reviews twice a year. The Senior Management Council reviews will ensure that sufficient progress is being made in meeting the Enterprise and Crosscutting Process performance targets.

These internal reviews will be useful in evaluating progress on targets with specific, quantitative measures, such as the demonstration of an advanced turbine combustor that delivers a 50-percent reduction of NOx emissions, relative to the 1996 ICAO standards. It is anticipated that NASA's extant management review processes will provide the most appropriate forums for both reporting and reviewing project and program performance data. Consistent with the streamlining of Agency processes, we do not plan to create new data collection and oversight processes for the program-specific performance targets. Our mission-oriented organizational structure and established management processes are well suited to assessing this type of performance evaluation.

A number of organizations will conduct the external reviews. In some cases, the organizations are advisory bodies that work with NASA to establish priorities in their particular scientific disciplines. In other cases, reviews are conducted by organizations such as the NASA Advisory Council, the National Academy of Sciences, and the General Accounting Office, which share responsibility for oversight of the Agency. The Occupational Safety and Health Administration and the Environmental Protection Agency will also provide reviews of performance unique to their agencies during the fiscal year. The use of these external reviews will allow NASA to assess whether our performance is adequately supporting the anticipated progress toward accomplishing the priorities established by our advisory bodies. If necessary, these external assessments may result in revisions to our strategic plans.

The Performance Report required by GPRA will include information from the internal and external assessments.

National Aeronautics and Space Act of 1958 and associated amendments
Available at: http://www.hq.nasa.gov/office/codez/policy.html

National Space Policy (1996)
Available at: http://www.whitehouse.gov/WH/EOP/OSTP/NSTC/html/fs/fs-5.html

Goals for a National Partnership in Aeronautics Research and Technology
Available at: http://www.whitehouse.gov/WH/EOP/OSTP/html/aero/cv-ind.html

NASA Strategic Management Handbook (NASA Procedures and Guidelines 1000.2)
Available at: http://www.hq.nasa.gov/office/codez/plans.html

NASA Performance Plan
Available at: http://www.hq.nasa.gov/office/codez/plans.html

Mission to Planet Earth Strategic Enterprise Plan
Available at: http://www.hq.nasa.gov/office/mtpe/stratplan.html

Space Science Strategic Enterprise Plan
Available at: ftp://galaxy.hq.nasa.gov/pub/OSS/Enterprise_Documents/

Human Exploration and Development of Space Strategic Enterprise Plan
Available at: http://www.osf.hq.nasa.gov/heds/hedsplan.html

Aero-Space Technology Strategic Enterprise Plan
Available at: http://www.hq.nasa.gov/office/aero/oasthp/library/leader.htm

Science Policy Guide
Available at: http://dlt.gsfc.nasa.gov/cordova/guide.html

Government Performance and Results Act of 1993
Available at: http://server.conginst.org/conginst/results/results.html

NASA values the comments and recommendations of our external stakeholders, customers, partners, employees, and contractor community. For further information regarding this Performance Plan, the Strategic Plan, or NASA's four Strategic Enterprise Plans, please contact the following individuals:

NASA Headquarters
300 E Street, SW
Washington DC 20546

NASA Strategic Plan
Associate Administrator

Lori B. Garver
Office of Policy and Plans
(202) 358-2096
E-mail: lori.garver@hq.nasa.gov

Earth Science

Dr. Ghassem Asrar
Associate Administrator
Office of Earth Science
(202) 358-2165
E-mail: ghassem.asrar@ hq.nasa.gov

Space Science

Dr. Edward J. Weiler
Associate Administrator
Office of Space Science
(202) 358-1409
E-mail: ed.weiler@hq.nasa.gov

Human Exploration
and Development of Space

Joseph H. Rothenberg
Associate Administrator
Office of Space Flight
(202) 358-2015
E-mail: joe.rothenberg@hq.nasa.gov

Dr. Arnauld E. Nicogossian
Associate Administrator
Office of Life and Microgravity Sciences and Applications
(202) 358-0122
E-mail: arnauld.nicogossian@hq.nasa.gov

Aero-Space Technology

General Spence M. Armstrong
Associate Administrator
Office of Aero-Space Technology
(202) 358-2693
E-mail: spence.armstrong@hq.nasa.gov

The NASA Performance Plan is also available on the World Wide Web on the Chief Financial Officer's Home Page: http://ifmp.nasa.gov/codeb/

National Aeronautics and
Space Administration

Washington, DC 20546