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National Aeronautics and
Space Administration

Budget Estimates

Fiscal Year 1996

Volume I

Agency Summary

Human Space Flight

Science, Aeronautics and Technology

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Agency Summary

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1996 BUDGET ESTIMATES

NASA'S VISION FOR THE FUTURE

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's unique mission of exploration, discovery, and innovation has preserved the United States' role as both a leader in world aviation and as the preeminent spacefaring nation. It is NASA's mission to:

- Explore, use and enable the development of space for human enterprise:
- Advance scientific knowledge and understanding of the Earth. the Solar System, and the Universe and use the environment of space for research:
- Research, develop, verify and transfer advanced aeronautics, space and related technologies.

The outcomes of NASA's activities contribute significantly to the achievement of America's goals in four key areas:

- Economic Growth and Security - NASA conducts aeronautics and space research and develops technology in partnership with industry, academia, and other federal agencies to keep America capable and competitive.
- Preserving the Environment - NASA studies the Earth as a planet and as a system to understand global change, enabling the world to address environmental issues.
- Educational Excellence - NASA involves the educational community in our endeavors to inspire America's students, create learning opportunities. and enlighten inquisitive minds.
- Peaceful Exploration and Discovery - NASA explores the Universe to enrich human life by stimulating intellectual curiosity, opening new worlds of opportunity, and uniting nations of the world in this quest.

To fulfill NASA's mission of exploration, discovery and innovation, NASA sets the following overarching goals to take its science and aeronautics program proudly into the 21st century:

- NASA will be at the forefront of exploration and science. We will develop and transfer cutting-edge technologies in aeronautics and space. NASA will establish a permanent human presence in space.
- As NASA pursues its mission, NASA will enrich the Nation's society and economy. NASA will contribute to a better life for this and future generations.
- In the longer term, it is our goal to undertake bold and noble challenges -- exciting future programs. such as the return of humans to the Moon and human missions to Mars, which stir the imagination and fall within the grasp of the United States and its international partners' technical and financial grasp.

STRATEGY FOR ACHIEVING OUR GOALS

The framework for achieving these goals is embodied in the **NASA** Strategic Plan, published in May 1994. The NASA Strategic Plan separates key **NASA** activities into five distinct Strategic Enterprises. They are:

- Mission to Planet Earth:
- Aeronautics;
- Human Exploration and Development of Space;
- Space Science, and.
- Space Technology.

Each Enterprise, similar to the strategic business units employed by the private sector, has a unique set of strategic goals, objectives, and concerns. and a unique set of primary external customers. NASA also provides capabilities that are required for each Enterprise to achieve its goals and meet the needs of their customers. These agency-level activities serve multiple Enterprises and the strategies of these functions are driven primarily by the strategic plans of the Enterprises. The fundamental values of excellence, responsibility, teamwork, trust, and honor form the bedrock of all of NASA's activities.

NASA's Strategic Plan transcends its organizational structure. Each of the Strategic Enterprises seek to respond to a unique customer community. At the same time, there is considerable synergy between the Enterprise activities which strengthens the activities of each. A broad description of the focus of each Strategic Enterprise follows:

Mission to Planet Earth - The activities which comprise this Enterprise are dedicated to understanding the total Earth system and the effects of humans on the global environment. This pioneering program of studying Global Change is developing many of the capabilities which will be needed indefinitely, for long-term environment and climate monitoring and prediction. Governments around the world need information based on the strongest possible scientific understanding. The unique vantage point of space provides information about the Earth's land, atmosphere, ice, oceans, and biota as a global system, which is available in no other way. In concert with the global research community, the Mission to Planet Earth Enterprise is developing the understanding needed to support the complex environmental policy decisions that lie ahead.

Aeronautics - NASA, and its predecessor, the National Advisory Committee for Aeronautics. have worked closely with **U.S.** industry, universities, and other Federal agencies to give the United States a preeminent position in Aeronautics. Future **U.S.** competitiveness in aeronautics. as well as the continued safety and productivity of the Nation's air transportation system, is dependent upon sustained NASA advances in aeronautics research and technology. The Aeronautics Enterprise will pioneer the identification. development, verification, transfer. application and commercialization of high-payoff aeronautics technologies. Activities pursued as part of this Enterprise emphasize customer involvement, encompassing U.S. industry, the Department of Defense, and the Federal Aviation Administration.

Human Exploration and the Development of Space - Human Space Flight serves as a foundation for much of what NASA does. Activities pursued as part of the Human Exploration and Development of Space Enterprise seek to bring the frontiers of space fully within the sphere of human activities for the benefit of America and all humankind in this and future generations. It will open the space frontier by exploring, using, and enabling the development of space. NASA was propelled into the space frontier, by an international political challenge born of the Cold War. With the Cold War behind us, we seek to work with other nations in our current and future activities, and to lay the foundations for human development of space.

Space Science - The activities of the Space Science Enterprise seek answers to fundamental questions. such as understanding the origin of the universe and our solar system, how they have evolved, and whether the Earth is unique, if there are planets around other stars and if life exists elsewhere. The quest for this information. and the answers themselves, maintains scientific leadership, excites and inspires our society, strengthens education and scientific literacy, develops and transfers technologies to promote U S. competitiveness, fosters international cooperation to enhance programs and share their benefits, and sets the stage for future space ventures.

Space Technology - Technology advances drive the ability of United States business to compete successfully in the global marketplace. Activities undertaken by the Space Technology Enterprise are focused on proactively transferring technology to aerospace and non-aerospace industries in order to enhance U.S. competitiveness: developing new and innovative space technologies to improve the performance and cost of future space missions: and, to developing technology to revitalize access to space. This specific focus on developing technology leading to new low cost launch systems will be done in partnership with U.S. industry, with the private sector playing a significant role in managing the development and operation of a new reusable space transportation system.

The Strategic Enterprises comprise an integrated national effort. Synergism of broad purposes, technology requirements, workforce skills, facilities, and many other dimensions was the basis for amalgamating these activities in NASA in the National Aeronautics and Space Act in 1958. and the benefits remain strong today.

ACCOMPLISHMENTS AND PLANS

The NASA budget request for FY 1996 is reflected in four appropriations:

Human Space Flight - providing funding for the Space Station and Space Shuttle programs, including payload and utlization operations and flight support for cooperative programs with Russia:

Science, Aeronautics and Technology - providing funding for NASA's research and development activities. including all science activities, global monitoring, aeronautics, technology investments, education programs, mission communication services and direct program support:

Mission Support - providing funding for NASA's civil service workforce, space communication services, safety and quality assurance activities, and maintenance activities for the NASA institution:

Inspector General - providing funding for the manpower and support required to perform audits and evaluations of NASA's programs and operations.

The President and his Administration are committed to a fundamental reshaping of the federal government, reducing its size, cutting its cost, eliminating unnecessary regulations, and improving service to its customers, the American public. The Administration has directed NASA and other federal agencies to reflect in this budget request for FY 1996 funding estimates for FY 1997-2000 derived by making percentage reductions to the FY 1996 request base. These estimates for NASA are substantially below the levels required to support previously approved programs and planned new initiatives. In response, NASA has underway an orderly process to examine the relative merits and funding requirements of all its programs and activities. The results of this review will not be available for several months.

This budget reflects the continuing revolution at NASA, which is changing the paradigm in the way the agency approaches its business, making it more relevant to America. The vision of NASA in the year 2015 starts with the FY 1996 budget request. Many of NASA's highest priority programs that will enable this vision are encompassed within the Administration's New Technology Investment initiative. The initiative will promote a new class of technology-intensive smaller, cheaper type of space missions. The initiative includes the following programs: Discovery, Explorer, Mars Surveyor, Small Spacecraft Technology Initiative, New Millennium Spacecraft, and the Small Booster Technology Testbed (X-34). These programs will experiment with new innovative management and procurement practices, and enforce strict adherence to performance criteria and a cost cap. An emphasis on low life cycle cost will enable more frequent solicitation and. hence, greater opportunities for participation by industry and academia. These programs will provide a higher technological and management standard from which future new ambitious programs will be based.

The New Millennium Program, proposed for initiation in FY 1996, will touch all facets of NASA's mission to explore space. It is the strongest signal that NASA is serious about changing the way it manages its programs, pursues technology development, and works in partnership with the private sector. In Space Science, the New Millennium Program will demonstrate new technologies to produce lower mass spacecraft capable of launching on lower cost launch vehicles, and for increasing spacecraft autonomy to reduce operations costs. The era of large spacecraft with complex instrument complements has given way to small, frequent, and affordable missions that will result in "virtual colonization" of the solar system and beyond. The questions raised by the initial reconnaissance of the solar system, combined with the desire to understand how common Earth-like planets are, require frequent, challenging missions to "mine" the solar system for knowledge and to better understand the potential for Earth-like planets around other stars. In Mission to Planet Earth, the New Millennium Program will result in advanced Earth Probes spacecraft that can be developed in a short time period to respond to new targets or phenomena of interest. In Space Access and Technology. special emphasis will be on enabling technology for this next generation of spacecraft. Advances in microsystem technology, and instrument detector technologies are required to meet the challenge of drastically reducing the size of future spacecraft, increasing their capabilities and lowering the cost. Industry will play a multifacted role in the New Millennium Program. They will be

involved in all aspects of the program. from technology development through science data processing. They will be aggressively sought out to identify and provide new technologies appropriate for demonstration on New Millennium Program flights. One of the key goals of the partnerships with industry is to ensure that at the end of the partnership, industry will be in a better position to compete effectively in aerospace and other commercial markets.

Funding is also included to initiate technology development for a new reusable launch vehicle. The challenge of reducing the cost to orbit goes in hand with the challenge of the New Millennium Program. Funding is included in this budget request to begin developing new technologies that will revolutionize access to space. The target of this program is to reduce launch costs to less than $1000 per pound to low-Earth orbit in the post-2000 timeframe. Each part of this closely integrated program contributes to the process of validating key component technologies, proving that they can be integrated into a functional vehicle, and demonstrating that they can be operated as required to make low-cost access to space a reality. The model for the relationship in this program among NASA, industry. and the Department of Defense (DoD) is a partnership. In forging this partnership. the emphasis is on mutual responsibility for the effort, mutual benefit from the research and design efforts, and mutual contribution of assets to the execution of the effort. This program is structured to eliminate the technology barriers so to allow the Government and industry to make an informed decision on whether to proceed with development of an operational next-generation reusable launch system.

NASA is also transforming itself to respond more effectively to the nation's future. NASA has been a leader in responding to the challenge of reducing the federal deficit and the goals of the National Performance Review. The five year budget requirement for NASA programs has been reduced 30% from the FY 1993 President's budget request. NASA has examined all of the agency's activities, from major flight programs to its individual research efforts, and has aggressively pushed the entire community involved in NASA's programs to gain the maximum value from every dollar spent. Every organization in NASA is performing a critical assessment of its own workforce. The NASA Streamlining Plan contains actions the agency is taking to reduce by 16.5% the number of NASA civil servants over the FY 1993 to 1999 timeframe. NASA is actively involved in the National Science and Technology Council (NSTC) Federal Laboratory review of the activities and functions of the Department of Defense, Department of Energy and NASA laboratories. A strengthened program management system has been implemented over the past year, and baseline reviews were conducted for all of NASA's major flight programs. The Program Management Council will regularly review the technical, schedule and financial status of NASA's major activities. A disciplined process has been established for the early identification of problems, and guidelines for addressing a solution. This process has resulted in senior management attention focused on program performance.

HUMAN SPACE FLIGHT

This appropriation encompasses all human space flight activities, including development of the Space Station and the safe and efficient operation of the Space Shuttle. During the past year, NASA has focused on putting a new Space Station program structure in place and transforming the outlines of the redesigned Space Station into detailed drawings. The program has emerged from the redesign process of 1993 with a strengthened program structure led by a single prime contractor, Boeing. The program office at the Johnson Space Center has primary management responsibility for the program. and is structured around integrated product teams with responsibility for bringing the systems and elements into integrated launch packages.

A Space Station Systems Design Review was completed in March 1994 which validated the current system design as meeting program requirements. The International partners - the European Space Agency, Japan, and Canada, the Russians, and the U.S. are pressing forward toward First Element Launch, scheduled for December 1997. Development, manufacturing and testing of Space Station hardware has continued through FY 1994, with approximately 25,000 pounds of flight hardware produced by the Space Station contractors. Planning activities for the operation and full utilization of the Space Station are well underway. The Mission Control Center (MCC) at the Johnson Space Center (JSC) will be the prime site for the planning and execution of integrated system operations of the Space Station, with exclusive command and control authority. The MCC at JSC and the Mission Control Center at Kalingrad form the unified command and control center for the Space Station. The Marshall Space Flight Center (MSFC) has responsibility for the payload integration and operations process. The payload integration process has been streamlined and shortened significantly from procedures used on the Space Shuttle. Standardized payload accommodation and an express rack concept have been incorporated for later payload manifesting. A Payload Operations Integration Center and user support facilities will be located at the MSFC as part of existing facilities that support the Shuttle/Spacelab activities and operation of the Advanced X-ray Astrophysics Facility (AXAF).

The highest priority of the Shuttle program remains the safe launch, operation and return of the orbiter and crew. Funding is included to continue modifications that will significantly improve the Space Shuttle's overall safety, including modifications to the Main Engine, Orbiter and Redesigned Solid Rocket Booster. In addition, funding for investments to improve Shuttle performance, such as the Super Lightweight External Tank, is included in order to satisfy Space Station requirements. At the same time, each Shuttle project has been working to a very aggressive cost reduction program. These efforts will continue through FY 1995 and FY 1996, through critical operational and workforce reviews of current requirements and exploring new ways of doing business.

In 1995, an American astronaut will spend approximately three months on the Russian Space Station Mir, an important first step in the planned U.S.-Russian cooperative space program. The Shuttle will rendezvous with the Mir in February 1995, during which important procedures will be tested that have direct application to the docking mission planned with the Mir in May 1995. Up to seven additional joint U.S. visits to the Mir are planned, which will provide approximately 24 months of on-orbit time to test science hardware planned for the Space Station. NASA has pursued an active program of cooperative activities in concert with Russia across the NASA program.

The Space Shuttle continues to provide its unique capabilities. The Space Shuttle successfully completed eight flights in FY 1994, including the highly successful Hubble Space Telescope (HST) Repair mission, two Spacelab module missions - the second Spacelab Life Sciences (SLS-2) and first International Microgravity Laboratory (IML-1) mission - as well as three pallet missions. The first mission of FY 1995 has already been completed, and six more are planned. During FY 1995, there will be two extended duration flights of thirteen to sixteen days, and in May 1995, the first docking of the Shuttle to the Mir is planned. During this mission, an astronaut and two cosmonauts, who will have been aboard the Mir for two months, will be picked up. Two cosmonauts, who will be aboard the Space Shuttle when launched from the Kennedy Space Center (KSC), will transfer to the Mir and replace the two who will return to KSC.

SCIENCE. AERONAUTICS AND TECHNOLOGY

Space Science

The Space Science program is designed to expand our scientific understanding of the Sun, solar system, and universe beyond Planet Earth. It seeks answers to fundamental questions, such as understanding the origin of the universe and our solar system, how it has evolved. and whether the Earth is unique: if there are planets around other stars: and, if Me exists elsewhere. The Space Science program supports two broad programs: Physics and Astronomy and Planetary Exploration. Each program conducts development, operation and research activities in their respective science disciplines.

The Space Science programs continues a robust program of flight development activities. In Planetary Exploration, funding is included to continue development activities on the Cassini mission to Saturn. scheduled for launch in October 1997 on a Titan IV launch vehicle. The first two Discovery missions, the Mars Pathfinder and the Near Earth Asteroid Rendezvous (NEAR) mission continue, with launches scheduled for December 1996 and February 1996 respectively. on Delta II launch vehicles. Funding is requested in FY 1996 to initiate the next Discovery mission. A Discovery mission development cost (phase C/D through launch plus 30 days) must be within $150 million (FY 1992 dollars) and the mission must be within 3 years from start of development. These missions are designed to ensure a continuous stream of new planetary science data and more frequent access to space - both of which are critical requirements for a robust science program in the future. In Physics and Astronomy, development activities on the Advanced X-ray Astrophysics Facility (AXAF) continue, with launch by the Shuttle scheduled for September 1998. With its unprecedented capabilities in energy coverage, spatial resolution. spectral resolution and sensitivity, the AXAF will provide unique and crucial information on the nature of objects ranging from nearby stars like our sun to quasars at the edge of the observable universe. Funding is also included for the continued development of Explorer missions, which conduct investigations of an exploratory or survey nature, as well as a number of instruments and payloads to be used on international satellites or on Spacelab missions.

Results from the newly refurbished HST dominated the world of astronomy during 1994. The results from Hubble touched on some of the most fundamental astronomical questions of the 20th century. including the existence of black holes and the age of the universe. Data from the Compton Gamma Ray Observatory uncovered evidence that gamma ray bursts are not limited to the Milky Way galaxy, a discovery called by one scientist as "one of the most spectacular astrophysical discoveries of the decade". Funding for the science data management, archiving, and science networking is continued. Funding is included to support ongoing servicing support and new instrument development for the HST. The HST Imaging Spectrograph (HSTIS) and Near Infrared Camera and Multi-object Spectrometer (NICMOS) are being developed for flight in 1997. and the Advanced Camera for flight in 1999.

Funding is proposed within Planetary Exploration to initiate a technology development program, the New Millennium Program. which will lead to a new generation of spacecraft. These smaller, more intelligent, less expensive spacecraft will not only revolutionize NASA's exploration programs, but have beneficial payoffs for the commercial spacecraft industry as well. The technologies which will be demonstrated, will advance the state of the art in the design, development and implementation of science spacecraft and instruments in the next century. Demonstration missions will be pursued which demonstrate the validity

of the high priority technologies needed to revolutionize space exploration, and exploit scientific opportunities as well. Funding is also included to initiate the Stratospheric Observatory for Infrared Astronomy (SOFIA), a cooperative program with Germany that will replace the aging Kuiper Airborne Observatory (KAO) and to initiate definition of a Space Infrared Telescope Facility to complement the HST and begin a new era in infrared astronomy.

In October 1994. NASA requested the National Academy of Sciences (NAS) to assemble a review panel to validate the technical feasibility and scientific merits of the Gravity Probe-B mission in light of other science priorities within the NASA budget. The Gravity Probe-B (GP-B) mission is a highly complex, technically challenging mission to test key elements of Einstein's General Theory of Relativity. The final results of this study are anticipated in June 1995. In the event the panel recommends continuation of the GP-B mission, equivalent offsets within the NASA budget must be identified.

Life and Microgravity Sciences

The Life and Microgravity Sciences program develops the utilization of space to understand the response of biological and materials systems to the weightless environment. Flight opportunities aboard the Space Shuttle in FY 1994 provided a rich preview of research work that will be conducted on the Space Station. In Microgravity Sciences, two dedicated Spacelab flights were flown, the second International Microgravity Laboratory flight (IML-2) and the second U.S. Microgravity Payload flight (USMP-2). In the area of Life Sciences, the second Spacelab Life Sciences (SLS-2) mission was flown in early FY 1994, eighty-two experiments were flown on IML-2, and the first experiments resulting from a cooperative space flight initiative with the National Institutes of Health were flown on STS-59. Funding is continued to support development of the experiment hardware for use on the Space Shuttle and Space Station. Work carried out by Life Sciences and Aerospace Medicine ensure the development of medical care and countermeasures to facilitate productive work and the health of humans in space. The U.S.-Russian cooperative program will benefit research in Microgravity and Life Sciences by providing early long duration research opportunities. In FY 1995. a study will be conducted to identify options which could lead to the development of a next-generation Extravehicular Activity system, or space suit, for use on the Space Station. The major objectives of any follow-on initiative would be to increase the productivity of the space suit as well as decrease the maintenance and logistics costs of the system.

Mission to Planet Earth

The Mission to Planet Earth (MTPE) program seeks to better understand the mechanisms that drive the climate and ecology of Earth, and how human activity is affecting the environment. NASA's base program combines ground-based measurements, laboratory studies, data analysis and model development with a progressive series of satellite missions to study cloud climatology, Earth radiation budget, ozone levels, atmospheric chemistry, and ocean circulation. This is just a first step. The capability to model and predict the consequences of global change is the ultimate objective.

The ongoing Mission to Planet Earth program is making critical near-term contributions to understanding the Earth as an integrated system as well as environmental issues, such as global warming and ozone depletion. In FY 1994. four Shuttle flights were dedicated to various studies of Earth, using powerful radars and lasers to penetrate cloud cover and map critical factors on a global scale. Data from satellites in orbit, such as the Upper Atmospheric Research Satellite (UARS) and Ocean Topography

Experiment (TOPEX)/Poseidon, and the Earth Radiation Budget Experiment (ERBE) are being used in multidisciplinary studies focused on understanding various aspects of the global environment. The Earth Observing System (EOS) is a key element in the Administration's U.S. Global Change Research Program, and NASA's major contribution to this effort. The EOS is a series of spacecrafts designed to provide long-term data sets for use in modeling and understanding global processes. The Earth Probes provide data in specialized areas, such as tropical rainfall. ocean wind speed and direction. and global ozone concentrations. The EOS Data Information System (EOSDIS) will provide the processing, storage. and distribution of the EOS science data and resulting scientific products. Funding is also included to continue development of the Landsat-7 spacecraft. Management responsibility for the spacecraft was transferred from DoD to NASA in FY 1994. Landsat-7 is scheduled to launch in 1998. The ground system is being developed by the Department of Commerce/National Oceanic and Atmospheric Administration.

Aeronautical Research and Technology

The Aeronautical Research and Technology (R&T) program provides a broad foundation of advanced technology to strengthen the United States' leadership in aviation. an industry which plays a vital role in the economic strength, transportation infrastructure and national defense of the United States. The NASA Aeronautics program provides the nation with leadership in high payoff critical technologies which are transferred to industry, the Department of Defense, and the Federal Aviation Administration for application to safe, superior and environmentally compatible U.S. civil and military aircraft, and for a safe and efficient National Aviation System. NASA's unique research capabilities contribute to the strengthening of America's aviation industry in many ways, and the FY 1996 program continues important investments required to pursue the high leverage technologies required to support both the subsonic and high-speed civil transport economic viability. In FY 1994, a significant augmentation to the Advanced Subsonic Transport (AST) program took place, and funding for continuation of all program elements is included in FY 1995 and FY 1996. Phase I of the High Speed Research (HSR) program is scheduled be completed in FY 1995. This six year effort, begun in FY 1990, is defining critical HSCT environmental compatibility requirements in the areas of atmospheric effects, community noise and sonic boom, and is establishing a technology foundation to meet these requirements. Phase II of the program, begun in FY 1994, is directed at developing and verifying, in cooperation with U.S. industry, the high leverage technologies essential for economic viability in addition to environmental compatibility. NASA is an active participant in the High Performance Computing and Communications (HPCC) program. and has pioneered the application of design and simulation software on parallel machines and developed the most widely accepted performance evaluation/tuning software for applications on parallel machines. The funding planned for FY 1995 and requested for FY 1996 will continue NASA's leadership role in this multi-agency program. No funding is requested for the National Wind Tunnel Complex, however legislative language is proposed to extend the availability of funds appropriated in FY 1995 until FY 1997. The industry/Government team is continuing to examine all options. refine cost estimates, and advance design to the point where industry and government will be able to decide whether to invest funds and have the confidence that the final product will fulfill all stated criteria and be delivered on time and within budget.

Space Access and Technology

The Space Access and Technology program leads NASA's efforts to develop advanced space technologies which support the development and application of technologies critical to the economic, scientific. and technological competitiveness of the U.S. and

to promote U.S. industrial preeminence through strengthened linkages between the private sector and NASA technology efforts. The highest priority of this program is to provide new and innovative space technologies to meet the challenges and lower the cost of future space missions. Lowering space mission costs requires development of technology to revitalize access to space, through the discovery and validation of new and innovative space technologies that will dramatically reduce the cost to achieve orbit, and development of detector technologies to optimize sensitivity and resolution across the electromagnetic spectrum. The Office of Space Access and Technology is also actively engaged in nurturing and expanding commercial space industries. by proactively developing, demonstrating and transferring NASA technology to aerospace and non-aerospace applications.

NASA is taking the lead in developing the technology for the next generation reusable space transportation system. This program, which will be pursued in close partnership with U.S. industry and the Department of Defense, will include systems engineering and concept analysis, ground based technology development, and a series of flight demonstrators - the DC-XA, the X-34 Small Booster and the X-33 Advanced Technology Demonstrator. Each part of this closely integrated program contributes to the process of validating key component technologies, proving that they can be integrated into a functional vehicle, and demonstrating that they can be operated as required to make low-cost access to space a reality. NASA is also employing an innovative management strategy for the Reusable Launch Vehicle (RLV) program, based on cooperative agreements between a variety of Government and industry participants. Current partners on the RLV program are contributing manpower, facilities and funds to the technology development effort. This cost-sharing will continue under the two new cooperative agreements planned for the X-34 and X-33, with industry contributions to the X-34 anticipated to be at least 50% of the total investment in the small booster program.

There are two major decision gates which will guide the pace of development for the X-33. The first. no later than December 1996 will be whether to proceed with the large scale flight demonstration. The second, by the end of the decade, will determine whether the Government and industry are going to move ahead with full-scale development of an operational launch system. Both decisions will be based on criteria established in early 1995 and agreed to by NASA, the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP), with the advice of an outside panel of experts such as the NASA Advisory Council. The program's progress toward meeting the criteria will be reviewed annually. The release of funds identified for development of the large scale flight demonstration phase will be contingent on agreement by the President that, based on successfully meeting those criteria, the program is ready to proceed to the next phase.

NASA is in the process of changing the way it does business in the area of technology transfer. The Agenda for Change is NASA's blueprint for the ways NASA will impart the benefits of its knowledge, capabilities and research efforts into the national economy and the way that NASA derives benefits from the technological strength of American industry. At the same time, the Office of Space Access and Technology (OSAT) is supporting programs in the areas of communications spacecraft technology. remote sensing, and biotechnology and materials processing that are aimed specifically at developing advanced technologies and systems concepts to benefit NASA programs, and to support the commercial development of space.

Funding for the Launch Services program, which was previously managed by the Office of Space Science, has been brought under the cognizance of the Office of Space Access and Technology. Overall program management responsibilities remain centralized within OSAT. Mission support costs provide for technical oversight, launch support and program management which will be

funded within the OSAT budget. However, funding for mission unique launch services is now budgeted within the respective program offices - the Office of Space Science, Mission to Planet Earth, and the Office of Space Communications.

Academic Programs

Science and mathematics achievement is an integral element of the National Education Goals, and NASA's efforts in the education arena strongly support making U.S. students first in the world in science and mathematics achievement by the year 2000. NASA's programs at the pre-college. college and graduate levels use NASA's unique mission and results to capture and channel student interest in science, mathematics and technology. as well as enhance teacher and faculty knowledge and skills related to these subjects. At the undergraduate and graduate level, programs are geared to providing opportunities for students and faculty to participate in NASA-sponsored research activities at NASA field centers.

NASA has made a commitment to playing a leadership role in strengthening the capabilities of minority universities and to increasing opportunities for students at Historically Black Colleges and Universities and Other Minority Universities (OMUs), primarily Hispanic-serving institutions and Tribal Colleges, to participate in and benefit from NASA's research and education programs. The FY 1996 budget request for the Minority University Research program significantly increases funding to Other Minority Universities. NASA will follow a comprehensive strategy to strengthen the infrastructure of OMUs, enhance mathematics, science, and technology education, and increase the opportunities for Hispanics, Native Americans, Pacific Islanders and people with disabilities to improve mathematics. science, and technology education outcomes in NASA's education programs.

Mission Communication Services

Support which is most directly related to NASA's science and aeronautics programs, including ground network support, mission planning for robotics spacecraft programs, suborbital mission support, and support to aeronautics test programs, is included in the Science, Aeronautics and Technology appropriation. Funds are included in this budget to operate and sustain NASA's Deep Space Network, Wallops Flight Facility (and subsidiary facilities), and the Western Aeronautical Test Range which provide support for NASA's robotic science, aeronautics and suborbital programs: and the Spaceflight Tracking and Data Network and the Space Network Control Center.

MISSION SUPPORT

Safety, Reliability, Maintainability and Quality Assurance

NASA is committed to providing leadership in quality management of science and engineering programs. The Office of Safety and Mission Assurance (OSMA) is responsible for the development and implementation of risk management practices and Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) practices into all NASA activities. The funding requested in FY 1996 will continue a wide range of activities underway through which SRM&QA practices are integrated into the earliest phases of development for space and aeronautics programs.

Space Communication Services

Funding for the operation, sustainment. and replenishment of NASA's Space Network is in NASA's Mission Support appropriation. This program supports the operation of the Tracking and Data Relay Satellites (TDRS), and the ground terminals at White Sands, New Mexico. Funds for services provided to non-science users of the TDRSS are included under this program. The NASA Communications (NASCOM) system and the Program Support Communications Network (PSCN) are also funded by this appropriation. In FY 1995. a contract for the development of three replenishment TDRSS spacecraft will be awarded, with availability planned to begin in 1999. The TDRS Replacement spacecraft, F-7, is scheduled for launch by the Shuttle in June 1995. As part of the National Performance Review, NASA has been tasked to explore how more of NASA's TDRS requirements could be met with broader-based commercial communications services.

Research and Program Management

The NASA workforce is the foundation underpinning the successful achievement of NASA's goals. Funding for the salaries, travel support and other personnel expenses for the entire NASA workforce is included. Funding for support activities to the NASA workforce and physical plant is also included in Research and Program Management.

NASA has exceeded all goals established by the President and Congress concerning the size of the NASA workforce. Through the overwhelmingly successful implementation of the Voluntary Separation Incentive (buyout) program, NASA reached their workforce goals established for FY 1995 by the end of FY 1994. NASA has reduced employment by approximately 8% of that reduction, at least 10% were in pay grades GS-14 and above. In concert with the redesign and restructuring of the Space Station program, the workforce level for this program has been reduced approximately 45%.

NASA is refining its strategies to implement the recommendations contained in the National Performance Review for streamlining components of the workforce and meet its FTE targets as part of the governmentwide effort to reduce the size of the government workforce by 272.900 by FY 1999. This strategy must assure that the NASA workforce is technically competent to meet the challenges of NASA's diverse and highly technical programs, while continuing the multiyear staff reductions and streamlining initiatives begun earlier. During FY 1995, each NASA installation is undergoing a workforce review including both civil servants and contractor support. It is anticipated that the preliminary conclusions from this review will be reached by mid-1995.

Construction of Facilities

Funding is included for discrete projects to repair and modernize the basic infrastructure and institutional facilities, the minor repair, rehabilitation and modification of exiting facilities, minor new construction projects, environmental compliance and restoration activities. the design of facilities projects, and the advanced planning related to future facilities needs.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION

FY 1996 BUDGET SUMMARY
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1994	1995	1996
HUMAN SPACE FLIGHT	6,074.3	5,514.9	5,509.6
SPACE STATION	1,939.2	1,889.6	1,833.6
US/RUSSIAN COOPERATIVE PROGRAM	170.8	150.1	129.2
SPACE SHUTTLE	3,558.7	3,155.1	3,231.8
PAYLOAD AND UTILIZATION OPERATIONS	405.6	320.1	315.0
SCIENCE, AERONAUTICS AND TECHNOLOGY	5,792.5	5,943.6	6,006.9
SPACE SCIENCE	1,920.9	2,012.6	1,958.9
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	507.5	483.1	504.0
MISSION TO PLANET EARTH	1,068.0	1,340.1	1,341.1
AERONAUTICAL RESEARCH AND TECHNOLOGY	1,067.2	882.0	917.3
SPACE ACCESS AND TECHNOLOGY	562.4	642.4	705.6
MISSION COMMUNICATION SERVICES	581.0	481.2	461.3
ACADEMIC PROGRAMS	85.5	102.2	118.7
MISSION SUPPORT	2,667.4	2,589.2	2,726.2
SAFETY, RELIABILITY AND QUALITY ASSURANCE	34.3	38.7	37.6
SPACE COMMUNICATION SERVICES	248.2	226.5	319.4
RESEARCH AND PROGRAM MANAGEMENT	2,175.6	2,189.0	2,202.8
CONSTRUCTION OF FACILITIES	209.3	135.0	166.4
INSPECTOR GENERAL	14.7	16.0	17.3
NATIONAL AERONAUTICAL FACILITIES		400.0	
TOTAL BUDGET AUTHORITY	14,548.9	14,463.7	14,260.0
TOTAL OUTLAYS	13,693.3	14,239.4	14,125.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1996 ESTIMATES
SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS

FISCAL YEAR 1994	TOTAL	Research & Development	Space Flight Control & Data Comm	Construction of Facilities	Research & Program Management	Inspector General
VA-HUD-INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1994 (P.L. 103-124)	14,551,399	7,529,300	4,853,500	517,700	1,635,508	15,391
FY 1994 EMERGENCY SUPPLEMENTAL APPROPRIATIONS ACT (P.L. 103-211)	16,800	4,200	-18.400	-25,000	56,000	
VA-HUD-INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1995 (P.L. 103-327)	-18,000				-18,000	
LAPSE OF FY 1994 UNOBLIGATED FUNDS	-1,266				-601	-665
TOTAL BUDGET PLAN	14,548,933	7,533,500	4,835,100	492,700	1,672,907	14,726

FISCAL YEAR 1995	TOTAL	Human Space Flight	Science, Aero & Technology	Mission Support	Inspector General	Nat'l Aero Facilities
VA-HUD-INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1995 (P.L. 103-327)	14,404,684	5,514,897	5,901,200	2,572,587	16,000	400,000
DEPARTMENT OF DEFENSE APPROPRIATIONS ACT, FY 1995 (P.L. 103-335)	60,000		60.000			
PROPOSED RESCISSION	-1,000			-1,000		
TOTAL BUDGET PLAN	14,463,684	5,514,897	5,961,200	2,571,587	16,000	400,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1996 ESTIMATES

SUMMARY OF RESOURCES REQUIREMENTS

Distribution of Program Amount by Installation
(Thousands of Dollars)

	Total			Human Space Flight			Science, Aeronautics and Technology			Mission Support		
	1994	1995	1996	1994	1995	1996	1994	1995	1996	1994	1995	1996
Johnson Space Center	2,190,015	1,798,192	1,922,403	1,604,300	1,318,300	1,415,400	231,081	128,352	147,726	354,634	351,540	359,277
Space Station Program Office	1,187,580	1,524,251	1,437,566	1,171,400	1,494,000	1,407,100	0	0	0	16,180	30.251	30.466
Kennedy Space Center	1,444,046	1,323,622	1,280,591	1.1 25,200	1,021,600	972,800	40,040	38,924	40,871	278,806	263,098	266.920
Marshall Space Flight Center	2,838,573	2,519,874	2,592,970	1,887,100	1,533,397	1,582,000	518,889	603.776	634.047	432,584	382,701	376,923
Stennis Space Center	90,736	103,830	106,928	39,500	51,200	45.700	10,559	15,920	19,849	40,677	36,710	41,379
Ames Research Center	632,670	602,410	666,427	0	0	0	447,756	423,034	477,475	184.914	179,376	188,952
Dryden Flight Research Center	97,164	105,465	94,048	5,700	6,100	5,600	51,700	49,200	46,000	39,764	50,165	42,448
Langley Research Center	674,820	657,797	699,239	1,600	900	600	443.964	426,044	467.033	229,256	230,853	231,606
Lewis Research Center	930,048	775,993	847,416	132,300	17,900	9,000	557,467	527,277	585,722	240,281	230,816	252,694
Goddard Space Flight Center	2,321,371	2,441,923	2,517,666	9.200	9,200	9,900	1,825,311	1,934,040	1,905,127	486,860	498,683	602,639
Jet Propulsion Laboratory	902,261	997,015	980,523	400	0	0	878.652	974,576	955,473	23,209	22,439	25,050
Headquarters	1,121,577	1,178,357	1,076,343	97,600	62,300	61,500	713,062	822.457	727,577	310.915	293,600	287.266
Undistributed:												
Construction of Facilities:												
Various locations	81,846	8,955	10,580	0	0	0	74,000	0	0	7,846	8,955	10,580
Facility Planning and Design	21,500	10,000	10,000	0	0	0	0	0	0	21,500	10,000	10,000
National Aeronautical Facilities	0	400,000	0									
Inspector General	14,726	16,000	17.300									
TOTAL NASA	14,548,933	14,463,684	14,260,000	6,074,300	5,514,897	5,509,600	5,792,481	5,943,600	6,006,900	2,667,426	2,589,187	2,726,200

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

ADMINISTRATIVE PROVISIONS

[INCLUDING TRANSFER OF FUNDS]

[Of the budgetary resources available to the National Aeronautics and Space Administration during fiscal year 1995, $59,003,000 are permanently canceled. The Administrator of the National Aeronautics and Space Administration shall allocate the amount of budgetary resources canceled among the agency's accounts available for procurement and procurement-related expenses. Amounts available for procurement and procurement-related expenses in each such account shall be reduced by the amount allocated to such account. For the purposes of this paragraph, the definition of "procurement" includes all stages of the process of acquiring property or services, beginning with the process of determining a need for a product or service and ending with contract completion and closeout, as specified in 41 U.S.C. 403(2).]

Notwithstanding the limitation on the availability of funds appropriated for "Human space fight", "Science, aeronautics and technology", or "Mission support" by this appropriations Act, when any activity has been initiated by the incurrence of obligations for construction of facilities as authorized by law, the amount available for such activity shall remain available until expended. This provision does not apply to the amounts appropriated in "Mission support" pursuant to the authorization for repair, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and facility planning and design.

Notwithstanding the limitation on the availability of funds appropriated for "Human space flight", "Science, aeronautics and technology", or "Mission support" by this appropriations Act, the amounts appropriated for construction of facilities shall remain available until September 30, [1997] 1998.

Notwithstanding the limitation on the availability of funds appropriated for "Mission support" and "Inspector General", amounts made available by this Act for personnel and related costs and travel expense of the National Aeronautics and Space Administration shall remain available until September 30, [1995] 1996 and may be used to enter into contracts for training, investigations, cost associated with personnel relocation, and for other services, to be provided during the next fiscal year.

[No amount appropriated pursuant to this or any other Act may be used for the lease or construction of a new contractor-funded facility for exclusive use in support of a contract or contracts with the National Aeronautica and Space Administration under which the Administration would be required to substantially amortize through payment or reimbursement such contractor investment, unless an appropriations Act specifies the lease or contract pursuant to which such facilities are to be constructed or leased or such facility is otherwise identified in such Act. The Administrator may authorize such facility lease or construction, if he determines, in consultation with the Committees on Appropriations, that deferral of such action until the enactment of the next appropriations Act would be inconsistent with the interest of the Nation in aeronautical and space activities.]

The unexpired balances of prior appropriations to NASA for activities for which funds are provided under this Act may be transferred to the new account established for the appropriation that provides funds for such activity under this Act. Balances so transferred may be merged with funds in the newly established account and thereafter may be accounted for as one fund to be available for the same purposes and under the same terms and conditions.

[The fourth proviso in the paragraph under the heading "Science, space, and technology education trust fund" in the Department of Housing and Urban Development—Independent Agencies Appropriations Act, 1989 (Public Law 101404, 102 Stat. 1014, 1028) is amended by striking out "for a ten-year period" and inserting in lieu thereof "hereafter".]

[Notwithstanding any other provision of law or regulation, the National Aeronautics and Space Administration shall convey, without reimbursement, to the City of Slidell, Louisiana, all rights, title, and interest of the United States in the property, including all improvements thereon, known as the Slidell Computer Complex, and consisting of approximately 14 acres in the City of Slidell, St. Tammany Parish, Louisiana: *Provided,* That appropriated funds may be used to effect this conveyance: *Provided further,* That in consideration of this conveyance, the National Aeronautics and Space Administration may require such other terms and conditions as the Administrator deems appropriate to protect the interests of the United States.] *(Departments of Veterans Affairs and Housing and Urban Development. and Independent Agencies* Appropriations Act, *1995.)*

Multi-Year Budget

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1996 ESTIMATES

The FY 1996 multi-year budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685). The Administration has directed NASA and other Federal agencies to reflect in this budget request for FY 1996 funding estimates for FY 1997-FY 2000 derived by making percentage reductions to the FY 1996 request base. These estimates for NASA are substantially below the levels required to support previously approved programs and planned new initiatives. In response, NASA has underway an orderly process to examine the relative merits and funding requirements of all programs and activities. The results of this review will not be available for several months.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
FY 1996 BUDGET ESTIMATES
(MILLIONS OF DOLLARS)

FY 1996 PRESIDENT'S BUDGET

	1994 PAST YEAR	1995 CURRENT YEAR	1996 BUDGET YEAR	1997	1998	1999	2000
HUMAN SPACE FLIGHT	6,074.3	5,514.9	5,509.6	5,333.6	5,207.8	5,110.5	4,850.2
UNRESOLVED PERCENTAGE REDUCTION				-110.0	-135.0	-203.0	-327.4
SPACE STATION	1,939.2	1,889.6	1,833.6	1,782.0	1,742.0	1,719.0	1,531.6
US/RUSSIAN COOPERATIVE PROGRAM	170.8	150.1	129.2	114.2	1.3		
SPACE SHUTTLE	3,558.7	3,155.1	3,231.8	3,243.5	3,319.4	3,335.4	3,370.8
PAYLOAD AND UTILIZATIONOPERATIONS	405.6	320.1	315.0	303.9	280.1	259.1	275.2
SCIENCE, AERONAUTICS AND TECHNOLOGY	5,792.5	5,943.6	6,006.9	5,901.4	5,838.9	5,748.8	5,820.9
UNRESOLVED PERCENTAGE REDUCTION				-152.7	-421.9	-584.1	-712.2
SPACE SCIENCE	1,920.9	2,012.6	1,958.9	1,811.9	1,637.6	1,527.0	1,546.3
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	507.5	483.1	504.0	523.1	537.2	591.6	608.0
MISSION TO PLANET EARTH	1,068.0	1,340.1	1,341.1	1,379.4	1,483.0	1,498.1	1,580.8
AERONAUTICAL RESEARCH AND TECHNOLOGY	1,067.2	882.0	917.3	996.8	1,085.0	975.9	873.7
SPACE ACCESS AND TECHNOLOGY	562.4	642.4	705.6	743.0	885.9	903.4	925.8
MISSION COMMUNICATION SERVICES	581.0	481.2	461.3	474.9	489.9	512.8	528.8
ACADEMIC PROGRAMS	85.5	102.2	118.7	125.0	132.1	138.9	143.3
FUTURE PLANNING					10.1	185.2	326.4
MISSION SUPPORT	2,667.4	2,589.2	2,726.2	2,644.4	2,589.9	2,535.4	2,480.8
UNRESOLVED PERCENTAGE REDUCTION				-175.1	-288.0	-399.2	-488.7
SAFETY, RELIABILITY AND QUALITY ASSURANCE	34.3	38.7	37.6	37.8	38.0	39.7	40.0
SPACE COMMUNICATION SERVICES	248.2	226.5	319.4	368.4	372.1	319.3	250.0
RESEARCH AND PROGRAM MANAGEMENT	2,175.6	2,189.0	2,202.8	2,258.0	2,296.6	2,325.6	2,379.5
CONSTRUCTION OF FACILITIES	209.3	135.0	166.4	155.3	171.2	250.0	300.0
INSPECTOR GENERAL	14.7	16.0	17.3	16.8	16.4	16.1	15.7
UNRESOLVED PERCENTAGE REDUCTION				-1.0	-2.1	-2.9	-4.1
NATIONAL AERONAUTICAL FACILITIES		400.0					
TOTAL BA	14,548.9	14,463.7	14,260.0	13,896.2	13,653.0	13,410.8	13,167.6

FY 1995 Changes

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CHANGES FROM FY 1995 BUDGET ESTIMATE TO FY 1995 CURRENT ESTIMATE
(Dollars in Millions)

HUMAN SPACE FLIGHT

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 Δ	FY 1995 CURRENT ESTIMATE
Space station	1939.2	1889.6	--	1889.6
Development	1918.2	1641.8	90.4	1732.2
Construction of facilities	--	20.2		20.2
Utilization support	21.0	96.6	-68.3	28.3
Operations	--	131.0	-22.1	108.9

CHANGE FROM FY 1995 BUDGET ESTIMATE

Funding for the Space Station remains at the requested level of $1889.6 million. Within this funding level, funding for Development has been increased $90.4 million, offset by reductions of $68.2 niillion in Utilization Support and $22.1 million in Operations. Total funding for the program is consistent with the cap of $17.4 billion through assembly complete.

This Operating Plan reflects the results of work accomplished over the past several months that resulted in a revised assembly sequence, rescoping non-prime hardware and support activities, and the cost convergence activity conducted this past summer with the prime contractor, the Boeing Company. Our current planning is for a contract to be signed with Boeing by the end of 1994. The funding increase in Development reflects the decision to purchase the FGB energy core ($20.0 million) from Russia, increased requirements to accommodate the Canadian Mobile Servicing System ($13.0 million), and increased prime contractor and flight hardware integration activities ($63.1 million). As an offset to these increases, non-prime activities have been reassessed and funding is reduced $29.7 million. Funding for reserves was increased $24.0 million to better balance risk across the program. Funding for the construction of the Neutral Buoyancy Laboratory (NBL) ($20.2 million) is included in Development. The budget plan envisioned the NBL being built at the Johnson Space Center. The NBL is required to support training for EVA and integration necessary for assenibly of the station. NASA is actively evaluating a potential alternative option to lease, and ultimately acquire, real estate and facilities at the Clear Lake Development Facility, Clear Lake, Texas, currently owned by McDonnell Douglas, for purposes of modifying an existing facility as an NBL and other purposes. NASA has recently briefed Committee staff on this option, and will notify the Committee in the near term of our proposed plan in this regard.

In Utilization Support, funding is reduced $68.3 million. *An* agreement was reached with the Office of Life and Microgravity Sciences and Applications to accommodate within their portion of the $2.1 billion annual total for Space Station and related activities, selected laboratory support equipment (LSE), express rack development and payload analytic integration (PAI) responsibilities, which reduced funding requirements $9.9 million. The remaining LSE and PAI activities were rescoped and aligned to meet the revised assembly sequence, resulting in a funding reduction of $27.2 million. Ground facilities supporting payload integration and operations were similarly reassessed, resulting in a funding reduction of $25.2 million. Program reserves were reduced $6.0 million.

Funding for Operations is reduced $22.1 million. This reduction reflects the realignment of the activities consistent with the new assembly sequence (-$15.1 million) and a reduction in the level of reserves (-$7.0 million).

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
U.S./Russian cooperation	170.8	150.1	--	150.1

NGE FROM FY 1995 BUDGET ESTIMATE

There is no change from the budget request **of** $150.1 million. Consideration is being given to flying four missions to the Russian space Station Mir using a Spacehab module in place of three Spacelab module missions. Several options are being evaluated: the results of this evaluation will be forwarded to the Committees when the analysis is complete.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 A	FY 1995 CURRENT ESTIMATE
Space shuttle	3,558.7	3324.0	-168.9	3155.1
Shuttle operations	2,549.0	2420.1	-4.8	2415.3
Orbiter & integration	586.9	483.3	44.9	528.2
Propulsion	996.0	1042.0	-35.0	1007.0
Mission and launch operations	966.1	894.8	-14.7	880.1
Safety and performance upgrades	1,009.7	903.9	-164.1	739.8
Orbiter improvements	204.3	191.8	3.0	194.8
Propulsion upgrades	579.5	512.8	-84.6	428.2
Flight operations & launch site equipment	191.6	187.0	-82.5	104.5
Construction of facilities	34.3	12.3	--	12.3

CHANGE FROM FY 1995 BUDGET ESTIMATE

This reduction reflects reductions directed by Congress in House Report 103-715: a general reduction of $140.0 million ($94.0 million for Space Shuttle; $46 million of the total $59 million reduction to the Human Space Flight appropriation directed for procurement savings); $30 million for the cancellation of the Checkout and Control Monitoring System (CCMS-II); and, $17 million for the termination of the fiber optic cabling system for the Orbiter. These savings are offset by an increase of $2 1.9 million, as a result of a reallocation of funding from Payload and Utilization Operations, and a decrease of $3.8 million which reflects other program changes.

The general reduction directed by Congress is accommodated in part, through the application of reimbursements received for the Japanese Space Flyer Unit ($30.5million) and a $30 million reduction in Advanced Solid Rocket Motor (ASRM) funding requirements. Final negotiations on the Advanced Solid Rocket Motor program have reduced the FY 1994 estimate by $30 million, which allows a reduction to the FY 1995 requirement. This change will be addressed in a FY 1994 Operating Plan update which will be forwarded in the near future. The remaining $79.5 million is accommodated through general reduction across the program.

Safety and Performance Upgrades (-$164.1 million)

Total funding for Safety and Performance Upgrades is reduced a net of $164.1 million. This reflects an net increase of $3.0 million for Orbiter Improvements, offset by a reduction of $84.6 million for Propulsion Upgrades and a reduction of $82.5 million for Flight Operations/Launch Site Equipment Upgrades.

Funding for Orbiter Upgrades is increased a net of $3.0 million. This reflects a reduction of $32.6 million as part of the reduction directed by Congress offset by a net increase of $35.6 million due to program changes. The reduction reflects termination of funding for implementation of fiber optics in the Orbiter payload bay (-$17.0) and the application of $15.6 million of the total $30 million savings from reduced FY 1994 ASKM requirements.

Funding for new program requirements is $37.3 million. Consistent with NASA's decision in March 1994, $27 million is included to support an Orbital Maintenance Down Period (OMDP) for Columbia (OV-102) at the Rockwell facility in Palmdale, California, rather than the Kennedy Space Center as was originally planned. Future OMDPs are planned for Palmdale as well. Rockwell International will consolidate its Downey and Palmdale Orbiter activities in Palmdale to achieve overall orbiter program savings. $8.3 million is included to proceed with production of the Simplified Aid for Extravehicular Rescue (SAFER), which was successfully demonstrated on STS-64. The total estimate for SAFER is $18.2 million: this project is being done in-house at the Johnson Space Center. Funding is increased $2.0 million to initiate development of a receiver to utilize the Global Positioning system for Shuttle missions. This is required because the Department of Defense has decided to phase out the current landing system utilized for Shuttle launches and landings by the year 2000.

Offsetting these increases, funding for the Multi-Function Electronic Display System (MEDS) has been reduced $18.1 million. and funding for the RCS Direct Acting Valve has been reduced $6.7 million. These reductions are achieved through rephasing program

requirements. Funding for other orbiter improvements is increased $21.7 million, which will provide for performance enhancements to support Space Station assembly ($10.1 million) and other program requirements.

Funding for Propulsion Upgrades is reduced $84.6 million. This reflects a reduction of $53.1 million as part of the general reduction directed by Congress and an additional reduction of $31.5 million due to program changes. The Congressional reduction is accommodated through application of the remaining $14.5 million of the $30 million anticipated savings from reduced ASRM requirements and an additional reduction of $38.6 million in the Super Lightweight Tank (SLWT). The total change in SLWT funding reflects the the contractor's current estimate of funding requirements for the initial FY 1997 launch program, as well as the deletion of the additional baseline External Tank (-$27.0 million) which had been carried as schedule insurance.

Funding for the Advanced Turbopump implementation has been reduced $9.6 million based on reestimated program requirements. The total cost of this program is consistent with the total program cost of $1,056.0, as directed by Congress. Other funding reductions include deferral of the implementation of the RSRM non-asbestos program (-$17.3 million), reduction in NASA's funding requirement at the SRM Nozzle Refurbishment facility at Iuka, MS (-$22.4 million), consistent with the agency's commitment to this facility, and deferral of planned main engine health monitoring activities (-$10.8 million). These reductions have been offset by the inclusion of $11.1 million begin development of a lighter-weight Solid Rocket Booster recovery parachute system, which is expected to result in significant Shuttle performance improvement, and the addition of SRB program reserves ($9.3 million).

Funding for Flight Operations/Launch Upgrades is reduced $82.5 million. This reflects a reduction of $33.6 million for termination of the CCMS-II activities as directed by Congress, and an additional reduction of $48.9 million due to program changes. The further reduction of $48.9 million reflects a reduction in funding for Flight Operations Upgrades of $47.0 million and a reduction in funding for Launch Support Equipment of $1.9 million. The reduction in Flight Operations reflects reduced funding requirements for the Shuttle Mission Simulator rehost activation (-$14.0 million), aircraft maintenance and operations (-$14 million) and other equipment purchases (-$19.0 million). In Launch Site Equipment Upgrades, funding for Hardware Interface Module (HIM) cards is reduced $5.8 million reflecting reduced unit costs. This reduction is offset by increased funding of $3.9 million for other Launch Support Equipment upgrades.

Space Shuttle Operations (-$4.8 million)

Funding for Shuttle Operations reflects a net reduction of $4.8 million. This reflects a reduction of $74.5 million as part of the general reduction directed by Congress, offset the the reallocation of $21.9 million for Multi-use Mission Payload Support Equipment (MMPSE) and Payload Support Operations to Shuttle Operations from the Payload and Utilization Operations budget line item, and an increase of $47.8 million for other program changes. To accommodate the reduction directed by Congress, funding for System Integration is reduced $44.0 million, and funding for the Redesigned Solid Rocket Motor (RSRM) is reduced $30.5 million. The reduction in Systems Integration is achieved through reduced manpower requirements: the reduction in the RSRM reflects application of reimbursement funding received for the Japanese Space Flyer Unit mission. The reallocation of $21.9 million from Payload Support Operations is intended to ease management of the program by separating the KSC payload ground

operations from the JSC payload-unique services from Payload and Utilization Operations. The increase of $47.8 millon to meet other program changes is addressed below.

In Orbiter, funding is increased $67.0 million to support a higher level of engineering support manpower than planned. Funding for the External Tank is reduced a net of $50.0 million. This reflects a reduction of $58.3 million for lower than planned subcontract and materials funding offset by an increase of $8.3 million for unplanned environmental compliance requirements. Funding for the Space Shuttle Main Engine is increased a net of $4.8 million, reflecting an additional $14.9 million to higher manpower levels than planned, offset by a reduction of $10.1 million due to revised hardware requirements. Funding for the Solid Rocket Booster is increased $17.3 million due to revised hardware requirements. Funding for the RSRM is increased $23.4 million. This reflects an increase of $2 1.9 million to meet unforeseen environmental compliance requirements and an increase of $15.9 million to continue a second source of ammonium perchlorate, offset by a reduction of $14.4 million for other program requirements. Funding for Launch and Landing Operations is increased $30.0 million to support higher launch processing manpower levels than planned. Funding for Mission Operations is reduced $44.7 million based on reduced program requirements.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Payload and utilization operations	405.6	356.2	-36.1	320.1
Spacelab	125.5	92.3	6.3	98.6
Tethered reflight	7.4	9.7	-2.3	7.4
Payload operations	85.1	62.6	-26.3	36.3
Advanced projects	7.2	15.2	-3.0	12.2
Engineering and technical base	180.4	176.4	- 10.8	165.6

CHANGE FROM FY 1995 BUDGET ESTIMATE

This reflects a general reduction of $2 1.2 million consistent with Congressional direction (which includes the remaining $13.0 million reduction for procurement reform). offset by an increase of $10.0 million for an additional Spacelab flight, the reallocation of $2 1.9 million for the Multiniission and Payload Support Operations to Shuttle Operations, and an additional reduction of $3.0 million reflecting program changes.

Funding for Spacelab is increased $6.3 million. This reflects Congressional direction to add an additional Life and Microgravity Sciences mission (+$10 million), a transfer of $300 thousand from the Tether Reflight program to Spacelab for increased support. and a reduction of $4.0 million due to operational efficiencies The Tether Reflight program is reduced an additional $2.0 million due to reduced program funding requirements. Funding for Payload Operations is reduced $26.3 million, reflecting the previously mentioned realignment of funding for the MMPSE and Payload Support Operations activities to Shuttle Operations ($21.9 million). Funding is reduced an additional $4.2 million as part of the general reduction directed by Congress and is accommodated through

savings from program consolidations and reduced workforce levels. Funding for Advanced Programs is reduced $3.0 million, and will be accommodated through deferral of planned new activities. In Engineering and Technical Base, funding is reduced $10.8 million as part of the general reduction directed by Congress. This reduction will be achieved by decreasing lower priority safety, maintainability and quality assurance activities (-$8.5 million), by consolidating existing contracts in Automated Data Processing activities (-$1.9 million), and by reducing procurements for science and engineering laboratory support equipment (-$1.0 million). These reductions are offset by increased support for minority university research activities (+$0.6 million)

SCIENCE, AERONAUTICS AND TECHNOLOGY

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Space science..	1715.7	1766.0	16.0	1782.0
Physics and astronomy..	1064.4	1058.7	41.0	1099.7
Advanced x-ray astrophysics facility..	239.3	234.3	--	234.3
Global geospace science	27.6	--	40.0	40.0
Relativity mission development	42.4	50.0	--	50.0
Payload and instrument development..	59.5	47.9	6.0	53.9
Explorer development	123.3	120.4	--	120.4
Mission operations and data analysis	405.2	441.7	-9.3	432.4
Research and analysis	71.1	71.1	4.3	75.4
Suborbital program..	69.5	67.2	--	67.2
Information systems	26.5	26.1		26.1

CHANGE FROM FY 1995 BUDGET ESTIMATE

The increase in funding reflects an increase of $40.0 million for the Global Geospace Science (GGS) mission, an increase of $6.0 million in Payload and Instrument Development, and an increase of $4.3 million in MO&DA. These increases are offset by a net reduction of $5.0 million in Mission Operations and Data Analysis (MO&DA). These changes reflect Congressional direction.

The funding increase for GGS is required to support launch delays of the Wind and Polar missions from mid- 1994 to November 1994 and November 1995, respectively. Technical progress in recent months has been very positive. The Wind spacecraft was launched successfully on November 1, 1994. Final integration and test activities on the Polar spacecraft were resumed in December upon final verification of the successful launch and operations of Wind.

The reduction of $9.3 niillion in funding for MO&DA reflects a reduction of $15 million in GGS Operations, an increase of $10 million for Hubble Space Telescope (HST) operations, and a reallocation of $4.3 million for Astrophysics research to Research and Analysis. The reduction in GGS operations is enabled by the launch delay of the Wind and Polar spacecraft. The increase in HST will be applied consistent with Congressional direction, as follows: $2.0 million for the Advanced Camera: $3.0 million for the Space Telescope Science Institute: and $5.0 million will be held in reserve until the FY 1996 budget is submitted in January 1995. As directed in House Report 103-715, an Announcement of Opportunity for the Advanced Camera was released in early September and final selection is targeted for early 1995. The total estimated cost of the Advanced Camera is $25-$40 million. The current program planning includes the installation of the Near Infrared Camera/Multi-Object Spectrometer and Space Telescope Imaging

Spectrometer as part of the second servicing mission in 1997 and the Advanced Camera in 1999. $4.3 million is reallocated from Mission Operations to Research and Analysis to provide consistency in activities funded in the Research and Analysis budget.

Funding for Instrument and Payload Development is increased $6.0 million to provide greater flexibility to manage payloads developed under this program.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Planetary exploration	651.3	707.3	-19.0	688.3
Cassini	266.6	255.0	--	255.0
Mars instruments	4.4	1..4	0.7	2.1
Mars surveyor program	14.6	78.4	-19.0	59.4
Discovery	127.4	129.7	--	129.7
Mission operations and data analysis	130.7	127.7	-10.5	117.2
Research and analysis	107.6	115.1	3.8	118.9

CHANGE FROM FY 1995 BUDGET ESTIMATE

This funding level reflects a reduction of $19 million for the Mars Surveyor program directed by Congress. The reduction will be offset by award fee returned by the Martin Marietta *Corp.* due to the failure of the Mars Observer spacecraft. In addition, a net increase of $3.8 million in Research and Analysis and an increase of $0.7 million in Mars '94 instruments is offset by a reduction of $10.5 million in Mission Operations and Data Analysis.

The increase in Research and Analysis reflects the reallocation of $10.3 million to increase the focused technology development for advanced spacecraft. This will support the infusion of new technologies into future missions, resulting in enhanced performance capabilities of spacecraft hardware with reduced mass, volume, power and cost requirements. This funding is offset by a reduction in funding in the Planetary flight support activity, enabled through successful efforts to reduce the operating cost for science missions at JPL. An increase of $0.7 million is included in the Mars '94 instrument program, due to a two year launch delay in the Russian program. This increase will continue support for project management and instrument teams in support of a launch in November/December 1996. This increase is offset by reductions within Planetary Research and Analysis, which will be accommodated by deferral of planned new activities.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Life and microgravity sciences and applications	507.5	470.9	12.2	483.1
Life sciences	186.8	145.6	-4.9	140.7
Research and analysis	55.1	51.9	-1.2	50.7
Flight experiments	131.7	93.7	-3.7	90.0
Microgravity research	175.0	128.9	3.0	131.9
Research and analysis	18.4	21.7	8.7	30.4
Flight experiments	156.6	107.2	5.7	101.5
Aerospace medicine	(2.7)	7.0	--	7.0
Shuttle/spacelab payload mission management and integration	108.7	112.4	0.6	113.0
Space station payload facilities	37.0	84.0	6.5	90.5

CHANGE FROM FY 1995 BUDGET ESTIMATE

This net increase reflects the addition of $5.0 million for the NASA-NIH protocol and the addition of $7.2 million for an additional Life and Microgravity Sciences Spacelab mission, planned for 1996. These increases are consistent with Congressional direction.

The augmentation of $5 million for the NASA/NIH collaboration will continue the research activities associated with the NASA/NIH Biotechnology NASA Research Announcement initiated in FY 1994. The additional funding will support development **of** advanced tissue culturing technology as well as the development of advanced protein crystallizaation technologies to advance structural biology. Total funding for the NASA/NIH program is $15.0 million in FY 1995, which includes $10.0 million within the Life Sciences base program for cooperative NIH investigations. Also within Microgravity Research, $3.7 million is transferred from Flight Experiments to Research and Analysis (R&A) to expand the microgravity community and ensure readiness for long-term research using the Space Station.

Funding for STS/Spacelab Payload Mission Management and Integration is augmented $7.2 million to fund a new Life and Microgravity Spacelab (LMS) mission, to be launched in mid-1996. The objective of this mission is to conduct peer-reviewed, scientific investigations in the fields of materials science, fluids physics, protein crystal growth, biotechnology, gravitational biology and space physiology. Mission costs will be minimized by utilizing experiment hardware already developed for other

flights. Additional FY 1995 funding requirements for the mission are estimated at $8.7 million, and will be allocated from unobligated balances within the Life and Microgravity program, consistent with Congressional direction.

Funding for Space Station Facilities is increased by a net of $6.5 million. Responsibility for laboratory support equipment has been transferred from the Space Station program, with $15.6 million reallocated to Space Station Facilities in FY 1995. This increase is offset by a reduction of $9.1 million consistent with the revised Space Station assembly schedule. This reallocation does not impact the content of activities included within the $2.1 billion annual budget for Space Station and related activities.

The establishment of the Aerospace Medicine and Occupational Health program reflects the consolidation of activities governing all medical operations within NASA and the development of requirements for operational medicine and operational medical research to support human spaceflight. Funding is reallocated from Life Sciences Flight Experiments (-$1.7 million), Life Sciences R&A (-$1.2 million), Microgravity Flight Experiments (-$2.0 million), and STS/Spacelab Payload Mission Mangement and Integration (-$2.1 million) for this activity. This program will include the clinical medicine activities previously budgeted under Life Sciences R&A. A high priority for this consolidated action will be to develop and support applications of space-age technology to U.S. and global health, and to promote innovations which utilize technology to improve health care education. It will also encompass the telemedicine activities previously included in the base program.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Mission to planet earth	1.041.5	1238.1	53.3	1291.4
Earth observing system	318.8	455.1	136.0	591.1
Earth observing system data information System	188.2	284.9	-54.3	230.6
Earth probes	96.4	82.0	-0.4	81.6
Landsat..	74.1	62.4	-62.4	(87.4)
ACTS	3.0	3.0	-0.7	2.3
GLOBE	(0.3)	(5.0)	5.0	5.0
Space station attached payloads..	25.9	9.8	-9.8	--
Payload and instrument development	--	19.5	--	19.5
Construction of facilities.	18.0	17.0	--	17.0
Applied research and data analysis	317.2	305.1	39.2	344.3

CHANGE FROM FY 1995 BUDGET ESTIMATE

This net increase reflects an increase of $136.0 million for the Earth Observing System (EOS) offset by the reduction of $9.8 million for the SAGE instrument. These changes reflect Congressional direction. The current estimate for EOS includes funding for

Landsat-7 development, which has been increased to reflect the transfer of $25.0 million from the Department of Defense, as directed in the FY 1995 Department of Defense Appropriations Act (P.L. 103-335)

The Global Learning and Observations to Benefit the Environment (GLOBE) program is an international science and education partnership to create a network of students in kindergarten through high school througout the world to make environomental observations, resulting in a global environmental view that can be shared with the science community. Consistent with **NASA's** FY 1995 budget submission, $5.0 million is included in the Mission to Planet Earth budget to support NASA's activities.

Total funding for the EOS and the EOS Data Information System (EOSDIS) is increased $56.7 million. This includes the augmentation of $35.1 million directed by Congress in House Report 103-715, and an increase of $62.4 million for Landsat, offset by a net reduction of $40.8 million reflecting other program changes.

The Operating Plan for EOS reflects the results of the EOS Rebaselining activity which was accomplished during the summer. This activity, which adjusted the program to be consistent with the reduced total funding plan established in the FY 1995 budget, has produced a program with more, smaller spacecraft. The results of the EOS Rebaselining transferred $34.8 million from EOSDIS to the EOS program. Funding for EOS is increased an additional $25 million, consistent with Congressional direction. This augmentation will support the development of EOS secondary payloads, specifically the SAGE-I11 payload for inclusion on an EOS flight of opportunity. A further increase of $19.8 million, reflecting the reallocation of funding for the Science and Investigator Computational Facilities to EOS from the EOSDIS budget, is offset by the reallocation of $27.7 million for the EOS Interdisciplinary Science and related activities to the MTPE Science program. Funding for the Landsat-7 program ($87.4 million) is included in the EOS program, and includes the transfer of $25 million from DoD consistent with Congressional direction. $1.1 million is reallocated to EOSDIS for the purchase of Landsat 4/5 data . $2.2 million is reallocated to support the GLOBE program.

Funding for the EOSDIS program is reduced a net of $54.3 million. Consistent with Congressional direction, funding for visualization techniques is increased $1.5 million and EOSDIS program reserves are increased $8.6 million. Offsetting this increase, funding is reduced $64.4 million, primarily reflecting the results of the EOS Rebaselining activity. This activity resulted in rephasing the EOSDIS program, and $34.8 million was transferred from the EOSDIS program to the EOS program. Funding for the Science and Interdisciplinary Computing facilities (-$29.7 million) was reallocated to the EOS program (+$19.8 million) and to the Applied Data and Research Analysis program (+$9.9 million) to reflect the management of the activities. $1.1 million is reallocated from the EOS program to the EOSDIS program to support purchase of Landsat 4/5 data. $1.0 million is reallocated to support the GLOBE program.

Total Funding for Earth Probes is reduced $0.4 million, to support the GLOBE program. In addition, funding for the Total Ozone Mapping Spectrometer (TOMS) is reduced $1.2 million, and reallocated to support the Tropical Rainfall Measurement Mission (TRMM). The realignment of funds is required to restore funding which was reallocated from the TRMM program in FY 1994 and to maintain required TRMM program funding. This reduction will be accommodated within program reserves.

Funding for Space Station Attached Payloads is reduced $9.8 million, reflecting Congressional direction to delete funding for the SAGE-I11 Space Station payload. A SAGE-111 payload is being developed for inclusion on an EOS Flight of Opportunity mission, and funding for that effort is included in the EOS budget.

Funding for Applied Research and Data Analysis and Related Activities is increased $36.2 million, reflecting the reallocation of $27.7 million for EOS Science activities from the EOS program and the reallocation of $9.9 million from the EOSDIS budget for the EOS Interdisciplinary Computing Facilities . This funding adjustment is intended to reflect the management of the science activities, and is a result of the EOS Rebaselining activity. $1.4 million is reallocated to support the GLOBE program. Consistent with Congressional direction, $3.0 is included in Information Systems for a regional ecosystem computer-based modelling project at the Ohio Supercomputer Cehter.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Space access and technology	512.8	608.4	-3.0	605.4
Advanced space transportation	109.1	103.1	59.0	162.1
Industry technology program	19.7	18.9	(18.9)	(18.9)
Spacecraft and remote sensing	183.3	143.3	1.0	144.3
Advanced smallsat technology	12.5	47.9	14.0	61.9
Space communications	(29.0)	23.7	-4.9	18.8
Space processing	19.5	19.2	-0.9	18.3
Flight programs	140.9	91.6	-42.5	49.1
Technology transfer	27.8	36.8	9.0	45.8
Small business and innovative research program	(110.9)	123.9	--	123.9

CHANGE FROM FY 1995 BUDGET ESTIMATE

Total funding is reduced a net of $3.0 million. This reflects the reduction of $40 million in Flight Programs offset by an increase of $2.0 million in Spacecraft and Remote Sensing and an increase of $35.0 million transferred to NASA from the Department of Defense (DoD) for the Advanced Transportation program. These changes are consistent with Congressional direction. In addition, several funding reallocations have been made to support program priorities. This new organization combines funding previously included in the Advanced Concepts and Technology budget line item.

Funding for Advanced Space Transportation is increased a net of $59.0 million. Total funding to support the Reusable Launch Vehicle (RLV) activity is $128.5 million, an increase of $64.0 million. Of the $59.0 million increase, $18.9 million is due to the inclusion of the Advanced Industry Technology Program (AITP)within the Advanced Space Transportation budget. The FY 1995 AITP solicitation will be dedicated to technology developments by industry to further the advanced technologies required for next

generation launch vehicles. Future solicitations in cooperation with U.S. industry will be focused on other high priority NASA R&D areas which show significant relevance to the U.S economy. The funds transferred to NASA from the DoD will be applied consistent with Congressional direction, contained in the FY 1995 Department of Defense Appropriations Act (P.L. 103-335). The President's National Space Transportation Policy, dated August 5, 1994, directed NASA to formulate a plan by November 5, 1994 for review by the Administration. NASA's role is to push the technology required for the development and demonstration of a next generation reusable launch system, in support of a decision to be made no later than December 1996 on whether to proceed with a sub-scale flight test to prove the concept. The FY 1995 funds will be used to: (1) upgrade the DC-X flight demonstrator to the DC-XA configuration, allowing a flight test in FY 1996; (2) initiate development of the Small Booster Technology Demonstrator: **(3)** evaluate alternative propulsion systems that may be used for the Advanced Technology Demonstrator; and, (4) begin preliminary design and systems trade studies for the Advanced Technology Demonstrator. The increase is offset by a reduction of $2.0 million, which is reallocated to the Technology Transfer program to support implementation of the "Commercial Technology Agenda for Change" strategy, and a reduction of $3.0 million in the ELV Technology program. This reduction will be accommodated by deferring tasks planned for FY 1995.

Direction was included in House Report 103-715 that funding in FY 1995 for the Solid Propulsion Integrity Program (SPIP) equal the amount included in FY 1994 for that activity. During FY 1994, a total of $9.8 million was obligated on the SPIP program, including $1.6 million of FY 1993 funds. This Operating Plan currently includes $7.6 million for the SPIP program. However, in accordance with direction received in the letter of December 15, 1994 from the House and Senate Committees on Appropriations, NASA is examining alternative funding sources to allow FY 1995 funding for SPIP to be increased to the FY 1994 level of $12.9 million directed by the Committees.

Funding for Spacecraft and Remote Sensing is increased a net of $1.0 million. The Space Communications program, which was previously a separate budget line, is now included in the Spacecraft and Remote Sensing program, an increase of $18.8 million. Consistent with Congressional direction, funding is increased $2.0 million to continue the software reuse and artificial intelligence program, which was initiated in FY 1994. Of the total reduction of $19.8 million, $14.0 million is reallocated to the Advanced Smallsat program, $3.5 million is reallocated to Advanced Space Transportation to support the Reusable Launch Vehicle activity, and $2.3 million is reallocated to the Technology Transfer program to support initiation of the "Commercial Technology Agenda for Change" initiative. This reallocation is accommodated by reducing planned funding increases for Commercial Remote Sensing activities, Earth Orbiting Spacecraft Technology activities, and commercial Applications and Sensors and Instruments. In addition, $5.0 million is included to support NASA's participation in the Next Generation Vehicle project ("Clean Car") initiative.

Funding for the Advanced Smallsat program is increased $14.0 million. The original plan called for selection of one 3-year mission and one 2-year mission. As a result of the Smallsat competition, two 2-year missions were selected, resulting in a larger funding requirement in FY 1995 than planned. Funding is reallocated from the Spacecraft and Remote Sensing program to meet this requirement.

Funding in Space Communications is reduced $4.9 million, and reallocated to the Advanced Space Transportation program (-$4.5 million) and Technology Transfer (-0.4 million) to implement the "Commercial Technology Agenda for Change" initiative. The remaining $18.8 million has been combined with the Spacecraft and Remote Sensing budget.

Funding for Space Processing is reduced $0.9 million, and is reallocated to Technology Transfer to support the "Commercial Technology Agenda for Change" initiative.

Funding in Flight programs is reduced $40.0 million consistent with Congressional direction, as a result of funding appropriated for the Commercial Middeck Augmentation Module in P.L. 103-211. *An* additional reduction of $2.5 million is included, and funding is reallocated to Technology Transfer to support implementation of the "Commercial Technology Agenda for Change" initiative. This reduction will be accommodated by reducing the number of flight experiments studies.

Funding for Technology Transfer is increased $9.0 million to implement the "Commercial Technology Agenda for Change" initiative. In response to the commercial technology focus outlined in the National Performance Review (NPR), the Administrator introduced the Agenda for Change in July 1994, in order to raise the importance of NASA's technology transfer mission to the level of the Agency's aeronautics and space R&D work. The Agenda for Change is introducing a new way of doing business at the NASA field centers. The Centers are now actively seeking opportunities to move their technology into the market place, analyzing technology at all stages of development and utilizing a new mix of business practices to establish collaborations with industry. Key to the success of this mission is for the Field Centers to have sufficient resources for implementation of the Agenda for Change. This involves the acquisition of experts and services for the Field Centers in the areas of dissemination and marketing, electronic networks, business practices, and metrics and evaluation. The $9.0 million increase will be used to augment each Field Center's capability to carry out the Agenda for Change. Funding for existing activities, such as the National Technology Transfer Center, are at the requested level.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Aeronautical research and technology	1,067.2	898.5	-16.5	882.0
Research and technology base	394.3	342.8	23.5	366.3
Systems technology programs	423.9	555.7	-8.0	547.7
High performance computing & communications	63.6	76.1	--	76.1
Materials and structures systems technology	25.7	24.3	--	24.3
Numerical aerodynamic simulation	48.1	46.2	--	46.2
High-speed research	197.2	221.3	--	221.3
Advanced subsonic technology	89.3	125.8	--	125.8
Hypersonics technology program	26.0	40.0	-8.0	(32.0)
Construction of facilities		22.0	--	22.0

CHANGE FROM FY 1995 BUDGET ESTIMATE

This reduction reflects a net increase in funding for the Research and Technology (R&T) Base of $23.5 million, comprised of a reduction of $10.0 million for rotorcraft activities offset by an increase of $1.5 million for hypersonic wind tunnels studies, and a decrease in funding for Hypersonics of $8.0 million. These reductions reflect Congressional direction. In addition, funding for the Hypersonics Technology program is included in the R&T Base.

The reduction of $10 million in the R&T Base eliminates all previously planned activity for the Rotorcraft Institutes. This reduction is offset by an increase of $1.5 million for hypersonic wind tunnels studies, as directed by Congress. NASA is currently working with the Department of the Army on possible joint activities which could result in a reallocation of funds to support activities in rotorcraft technology

The reduction of $8.0 million in the Hypersonics Technology Program will be accommodated by reducing research in selected areas. Research will be concentrated on ramjet/scramjet flowpath optimization and test.

	FY 1994 ACTUAL	N 1995 BUDGET ESTIMATE	△	CURRENT ESTIMATE
Launch services	303.5	340.9	-7.0	333.9

CHANGE FROM FY 1995 BUDGET ESTIMATE

This reduction reflects direction from Congress to reduce funding for the Cassini launch vehicle by $7.0 million. This reduction can be accommodated as a result of recent negotiations between NASA and Martin-Marietta on total funding requirements for the integration of the Cassini spacecraft with the Titan IV/Centaur launch vehicle. In support of NASA's emphasis on reducing the size of scientific missions, NASA intends to procure a Medium-Light performance class of launch services from the commercial ELV sector. To support the preliminary design schedule of the Mars Surveyor series of spacecraft, which will be the first user of the med-light vehicle, $2.5 million is included for initial procurement activities. These preliminary design activities are required to support the 1998 planetary launch window for these missions.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	△	FY 1995 CURRENT ESTIMATE
Mission communication services	581.0	481.2	--	481.2
Ground network	309.3	273.4		273.4
Mission control and data systems	206.5	175.8	--	175.8
Space network customer services	30.0	32.0	--	32.0
Advanced systems	19.6	--	--	--
Construction of facilities	15.6	--	--	--

CHANGE FROM FY 1995 BUDGET ESTIMATE

There is no change to the budget request, however reallocations have been made within the program to meet program requirements.

Within Ground Network, funding increases are included for Deep Space Network (DSN) Systems Implementation and the Spaceflight Tracking and Data Network (STDN). Offsetting reductions are included for Deep Space Network Operations, the Aeronautics, Balloons, and Sounding Rocket (ABSR) program, and STDN Operations.

The increase in DSN System Implementation reflects several programmatic and accounting changes. $18.0 million is reallocated from DSN Operations to reflect a decision to consolidate funding for systems management, engineering and sustaining investment. Funding is increased $9.0 million for advanced systems technology activities, $1.8 million for an additional system capability in Australia in support of the Galileo mission, and $3.6 million for the continued outfitting of a 34 meter antenna transferred to NASA from the Department of the Army. As an offset to these increases, funding is reduced $15.4 million, principally accommodated by deferral of Cassini X-band emergency services at the Goldstone 70 meter antenna (-$3.7 million), by descoping several DSN automation projects (-$2.5 million), and by deferral of upgrades for the Very Long Baseline Interferometry and radio science programs (-$2.8 million). The remainder of the reduction will be accommodated through deferral of planned activities.

Funding for DSN Operations is reduced $17.9 million, which represents the aforementioned reallocation of funding for systems management to DSN Systems Implementation. The increase of $7.3 million in STDN Systems is required to support automation of the Bermuda and Memtt Island, Florida tracking facilities. To offset this requirement, funding for the AB&SR Systems is reduced $3.2 million, which will be accommodated by deferral of radar refurbishment activities at the Wallops Flight Facility and deferral of equipment purchases for the Western Aeronautical Test Range. Funding for STDN Operations is reduced $3.2 million, and will be accommodated through operational efficiencies.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Academic programs	85.5	97.2	5.0	102.2

CHANGE FROM FY 1995 BUDGET ESTIMATE

This increase is consistent with Congressional direction, and will be divided equally between the Historically Black Colleges and Universities (HBCU)and Other Minority Universities (OMU)programs. As directed in House Report 103-715, this augmentation will be used to support Institutional Research awards and Minority University-Space Interdisciplinary Network Awards (MU-SPIN), and to support Math and Science initiatives at HBCUs, Hispanic-serving institutions, and Institutions serving students with disabilities. These programs use the competition and peer review process for selection.

MISSION SUPPORT

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 Δ	FY 1995 CURRENT ESTIMATE
Safety, reliability & quality assurance	34.3	38.7	--	38.7

Although there is no change in total funding for Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) activities, funding has been reallocated to support program changes.

Within the total SRM&QA funding, program responsibility for several ongoing engineering projects has been assigned to the Office of the Chief Engineer and a new program element has been established. Funding for these programs totals $5.9 million; however, the funds will continue to be reported within SRM&QA. Of the total, $3.6 million will be used for NASA engineering policy and standards activities, and $2.3 million supports projects focused on demonstration of critical technologies needed for future NASA flight programs.

Within the Policy, Oversight and Standards program, $2.2 million is reallocated to support independent assessment activities for the International Space Station in FY 1995. This reallocation is accommodated from available program reserves and realignment of program activities. The total NASA level of funding planned for the Independent Validation and Verification (IV&V) facility remains at $17.5 million, distributed among the SRM&QA, EOS and Space Station budgets.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 Δ	FY 1995 CURRENT ESTIMATE
Space communications services	248.2	268.9	-60.0	208.9
Space network	117.7	154.0	-60.0	94.0
Telecommunications	130.5	114.9	--	114.9

CHANGE FROM FY 1995 BUDGET ESTIMATE

This funding level reflects Congressional direction to reduce funding for the Tracking and Data Relay Satellite (TDRS) Replenishment by $60 million. Contract award is still planned for the second quarter of FY 1995. House Report 103-715 indicates that NASA may reallocate up to $25 million of reimbursement funding and underruns to augment funding for the TDRS Replenishment as long as this does not result in any involuntary reductions-in-force in 1995 in the Space or Mission Communications Services programs. This Operating Plan is premised on complying with Conference Report direction to use FY

1994 carryover funds from reimbursable activities and underruns to prevent involuntary layoffs in the ongoing mission communications and space communications services programs. This plan does not extend to contractor employment actions pursuant to normal contract transitions, e.g., from competion of development to operations of the Second TDRS Ground Terminal. After we are confident that this direction has been observed, it is our plan to submit an Operating Plan update to reallocate additional funds to the TDRS Replenishment program.

Within Space Network, $7.2 million is transferred from the TDRS System to the Space Network Services program, to consolidate funding for the operation and support of the White Sands Ground Terminal (WSGT) with funding for the Space Network Services program. As the Second TDRS Ground Terminal becomes operational, and the WSGT is taken off line for refurbishment and upgrade, funding for the support of these two operations will be provided in this consolidated program element. The operations of the two ground terminals will be combined under a single contract beginning in FY 1996. Within the STGT program, increased funding to support the six month slip reported in the July 1994 PSR is accommodated within program reserves.

Funding for the Telecommunications program is unchanged, and reflects the combined funding for the NASA Communications Network (NASCOM) and the Program Support Communications Network (PSCN).
This net reduction of $154.5 million reflects Congressional reductions of $217.4 million, partially offset by the addition of $62.9 million to accommodate new requirements.

		FY 1995		
	FY 1994 ACTUAL	BUDGET ESTIMATE	△	CURRENT ESTIMATE
Construction of facilities.....	209.3	135.0	--	135.0

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Research and program management	2,175.6	2220.0	-31.0	2190.0
Personnel and related cost	1,634.0	1,684.5	-30.0	1654.5
Travel	38.9	48.7	--	48.7
Research operations support	502.7	486.8	-1.0	485.8

CHANGE FROM FY 1995 BUDGET ESTIMATE

This reduction is consistent with Congressional direction. The total funding for Research and Program Management (R&PM) is $2,190.0 million, which includes the $18 million rescinded from P.L. 103-715 and reappropriated in P.L. 103-327. Within R&PM, $1,654.5 is included for Personnel and Related Costs, $48.7 million is included for Travel, and $485.8 million is included for Research Operations Support (ROS). The reduction of $1.0 million in ROS reflects the proposed rescission by the Administration to reduce funding for administrative aircraft operations.

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
Inspector general	14.7	16.0	--	16.0

	FY 1994 ACTUAL	FY 1995 BUDGET ESTIMATE	FY 1995 △	FY 1995 CURRENT ESTIMATE
National aeronautical facility	--	--	400.0	400.0

Special Issues

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1996 ESTIMATES
ANALYSIS OF NASA/RUSSIAN COOPERATIVE MIR PROGRAM

	FY 1994	FY 1995	FY 1996
		(Thousands of dollars)	
HUMAN SPACE FLIGHT			
US-Russian cooperative program*	170,800	150,100	129,200
(Russian support)	(100,000)	(100,000)	(100,000)
(Mir)	(70,800)	(50,100)	(29,200)
Space station (Flight technology demonstrations)*	--	30,000	10,400
SCIENCE, AERONAUTICS AND TECHNOLOGY			
Russian cooperation*	52,900	61,600	63,100
(Life sciences)	(31,500)	(16,600)	(20,800)
(Microgravity)	(10,200)	(11,300)	(9,300)
(Spacelab mission management)	(11,200)	(27,700)	(23,000)
(Space access and technology)	(--)	(6,000)	(10,000)
Total	223,700	241,700	202,700

* Russian cooperation program elements are also included under the special analysis of the Agency's Space Station-related support.

The cooperative U.S.-Russian Mir program consists of seven (with a capability of ten) flights of the Space Shuttle to the Mir Space Station with the objective of conducting a joint experiment program for microgravity and life sciences and a technology demonstration program to mitigate risk involved in the development of the international Space Station, as well as extending the useful life of the Mir station through 1997. The initial flight of this joint program is scheduled for mid-1995. A minimum of five flights will carry pressurized experiments and other hardware to the Mir -- the first in a Spacelab module, with four others via a pressurized Spacehab carrier. During this period, Russia will enhance the Mir capabilities by adding two experiment/logistics modules to the core Mir station (Spektr and Priroda), which will also carry U.S. hardware. Other flights will supply logistics and Mir life-extension hardware, and conduct flight technology demonstrations.

The Russian support funding provides for hardware and services provided by Russia on a firm, fixed-price contractual basis which will benefit the joint Mir activities (Phase 1) as well as future Space Station-related design, technologies and other services (Phase 2/31.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1996 ESTIMATES
ANALYSIS OF AGENCY SUPPORT FOR SPACE STATION

	FY 1994	FY 1995	FY 1996
		(Thousands of dollars)	
HUMAN SPACE FLIGHT			
Space station	1,939,200	1,889,600	1,833,600
Russian cooperation	70,800	50,100	29,200
SCIENCE, AERONAUTICS & TECHNOLOGY			
Life and microgravity sciences and applications			
Russian cooperation	52,900	55,600	53,100
(Life sciences)	(31,500)	(16,600)	(20,800)
(Microgravity)	(10,200)	(11,300)	(9,300)
(Spacelab mission management)	(11,200)	(27,700)	(23,000)
Space station facility payloads	37,000	90,500	137,300
Space station utilization			
(Life sciences)		500	4,200
(Microgravity)	6,100	11,800	16,200
Mission to planet earth space station attached payload	--	--	4,100
Space Access and Technology Space Station Utilization	--	15,000	37,100
Total	2,106,000	2,113,100	2,114,800

Space station-related activities are funded in the Human Space Flight (HSF) appropriation and in the Science, Aeronautics & Technology (SAT) appropriation. Activities funded in the HSF appropriation include the development and operation of the Space Station, and the flight support component of the Russian cooperation program of joint flights to the Mir Space Station. Both programs are managed by the Office of Space Flight. Space Station-related funding in the SAT appropriation provides for the development, operation and science research associated with the scientific, technology and commercial payloads being built for utilization of the Space Station or in conjunction with the joint Mir program. The majority of these activities are managed by the Office of Life and Microgravity Sciences and Applications for these discipline-specific experiments. An externally-attached Space Station payload is being developed by the Mission to Planet Earth program. The Space Access and Technology program is providing technology and commercial payloads for both external and pressurized Space Station deployment.

National Aeronautics and Space Administration

Major NASA Development Programs
Program Cost Estimates

This special section of the FY 1996 budget justifications provides information about major NASA programs that are either in the design and development phase or have not completed their initial operational phase. In several instances, information about programs which are not "major" but are of special interest has been included. The budgetary estimates are expressed in millions of dollars of *budget authority.** Estimates of the FY 1994 and prior fiscal year budget authority are the "actual" amounts. The FY 1995 amounts are consistent with the NASA Operating Plan as of January 1995. The amounts for FY 1996 and future fiscal years are expressed in "real year" economics, that is. they include an adjusting factor for the future inflation expected to be experienced. If the term "constant dollars" is used in the budget justifications. that phraseology indicates that the numbers do not include inflationary adjustments beyond the fiscal year referenced (e.g., "constant FY 1994 dollars").

The estimates provided below are intended to be comprehensive, including all related mission-unique costs, but there are limitations. The direct and indirect costs incurred by foreign governments or other federal agencies in support of these missions have not been included. (The reader is referred to the NASA Program Status Reports, a biannual document published by NASA, for the most accurate information available to NASA on the amounts incurred or to be incurred.) The estimates of civil service workyears for these missions are not available at this time, but will be provided to the Congress as soon as practicable. following the completion of the civil service workforce review now being conducted by NASA. This review was undertaken in response to the direction from the Administration and Congress to cut the government's total civil service population by 272,900 by 1999. The NASA workforce review will study how the reductions in the NASA workforce should be made to meet our 1999 target.

**Budget authority* is a term used to represent the amounts appropriated by the Congress in a given fiscal year: *budget authority* provides government agencies with the authority to obligate funds. The ensuing obligations, cost incurrence, and expenditures (outlays) can differ in timing from the fiscal year in which Congress provides the *budget authority* in an appropriations act.

High Speed Research Program

The High Speed Research Program is a cooperative government-industry program to develop the technologies required by U.S. firms to design and build an environmentally compatible and economically competitive high-speed civil transport aircraft for the post-2000 period. The program consists of two phases, Phase I was initiated in FY 1990. Research was initiated at that time into environmental issues, such as atmospheric effects (e.g., ozone depletion), take-off and landing noise levels, and sonic booms for overland flight. Potential technology solutions have also been investigated. Phase II began in FY 1994, following a presentation of the encouraging preliminary results from Phase I activities. This phase involves both government funding and industry contributions of facilities, personnel, and supporting R&D. Development and validation of specific airframe and engine designs, design tools, and technologies for manufacturing processes are underway. This phase will conclude in 2001. It should be noted that the government funding does not provide for the development of a prototype aircraft.

The budgetary estimates provided below are the amounts included in the specific budget justification within the Aeronautics section in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts being contributed by industry, NASA civil service workforce salary and expenses (S&E), and the use of government facilities and general support used to carry out the research. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
HIGH SPEED RESEARCH	261.9	197.2	221.3	245.5	276.7	286.2	211.6	127.3	58.8	1,886.5

Advanced Subsonic Technology

The Advanced Subsonic Technology program is a cooperative government-industry program to develop technologies in areas where such developments will facilitate the economic and technological competitiveness of U.S. subsonic aircraft producers. These developments include not only airframe. engine, and avionics technology improvements, but also short-haul aircraft, environmental studies, efficiency and safety improvements, advanced air traffic technology. and aircraft design and manufacturing tools. This systems technology program was preceded by activities funded within the research and technology base for many years: the decision to create a focused program was made in the FY 1991 budget. The specific objectives set forth for this program are intended to be completed by FY 2002.

The budgetary estimates provided below are the amounts included in the specific budget justification within the Aeronautics section in the Science, Aeronautics and Technology appropriation for this program. As such, they do not include the amounts being contributed by industry, NASA civil service workforce salary and expenses (S&E), and the use of government facilities and general and administrative support used to carry out the research. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
ADVANCED SUBSONIC TECHNOLOGY	17.4	89.3	125.8	188.4	216.9	257.3	244.0	182.2	142.0	1,463.3

International Space Station

In FY 1983, NASA received approval to enter into a preliminary definition phase of a space station. A cost target was established at that time by President Reagan: this target provided guidance to the team undertaking the definition of what capabilities a space station could have for this amount of money. Due to the uncertainty of future inflation, the target was expressed in constant 1984 dollars. The target value of $8 billion was intended to cover the costs which would be incurred to perform the preliminary definition and the development of space station hardware and ground systems. The President also directed NASA to solicit the involvement of international parties in the space station.

After three years studying numerous design concepts, a final reference design was established by NASA and our international partners--Japan, Canada, and the member nations of the European Space Agency. Prior to requesting from the Administration and Congress the authority to proceed into the development phase, NASA undertook a comprehensive cost estimate. The resultant estimate of $14.5 billion (expressed in 1984 dollars for comparison purposes) was presented to the Administration in early 1987. After consideration, the Administration directed a National Research Council (NRC) review of the reference design and the cost estimate. The NRC reported back that the space station could be built in two phases, with the second phase adding the dual keel configuration, the co-orbiting platform, servicing capabilities, and additional solar dynamic power modules. The NRC included in its estimate of $21.0-25.0 billion (1984 dollars), a number of additional cost elements : operations, marginal Shuttle flight costs, a crew rescue vehicle, civil service salaries and expenses, facilities, and provision for additional testing and backup hardware. These estimates were furnished to the Congress in mid-1987 for their review prior to action on NASA's FY 1988 appropriation.

Over each ensuing year, Congress approved continuation of the Space Station Freedom program, but reduced each year's appropriations request. On several occasions, Congress directed NASA to redesign the Station to conform not only to the reduced appropriations request in that year but also to reduced projections of future funding availability for NASA's overall budget. In early 1993. President Clinton directed NASA to undertake a 90 day study of lower cost redesign options for the Space Station, and appointed an Advisory Committee on the Redesign of the Space Station. In June 1993, upon receiving the final reports and the Advisory Committee's recommendations, President Clinton selected an option (A) from the three options presented and directed NASA to execute the Space Station program for no greater than $2.1 billion per year. This figure encompassed not only the development and operational costs of the Space Station itself but also the costs for a program of precursor scientific research, the expenses for integrating the Space Shuttle and the Space Station and the development of experimental facilities and capabilities for the Space Station. The cap excluded the costs of civil service salaries and expenses, Space Shuttle operational flight costs, and performance improvements to the Shuttle.

In the Fall of 1993. President Clinton invited the Russian Government to become a participant in the program. The Russians offered access to their Mir space station in the interim period between 1995 and the beginning of the international Space Station's assembly. The Congress and Administration agreed in late 1993 that the $100 million amount to be paid annually to the Russian

Space Agency for hardware and services over the FY 1994-97 period was outside the $2.1 billion annual cap. Since late 1993, the U.S. and the newly expanded set of international partners have proceeded with the final design and hardware development for an international Space Station with significantly greater capabilities for research than those which would have been provided on Space Station Freedom or the option selected in the redesign process.

The budgetary estimates provided below include the amounts for this program in both the Human Space Flight and the Science, Aeronautics and Technology appropriations . The totals provide the current estimate for the costs to be incurred through the date when the completion of assembly milestone in June 2002 is accomplished. They do not include the amounts being contributed by the international partners, the NASA civil service workforce salaries and expenses (S&E), the $400 million contract with the Russian Space Agency, the costs of the non-program unique NASA facilities, Shuttle performance improvements and flight operations costs, and the general and administrative support used to execute the program. The present cost estimate for the average costs of the 19 Space Shuttle flights for assembly of the U.S. elements is $9.8 billion. An additional 6 Shuttle flights will be made for science and technology utilization purposes before June 2002: at average costs, these utilization flights are estimated at $3.1 billion. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the budget justifications for the Space Station: Russian cooperation: Payload Utilization and Operations: Life and Microgravity Sciences and Applications: Space Access and Technology; and. Mission to Planet Earth.

International Space Station

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
PROGRAM ELEMENTS WITHIN $2.1 BILLION ANNUAL FUNDING CAP		2,106.0	2,113.1	2,114.8	2,120.9	2,098.1	2,106.8	1,950.2	2,750.0	17,359.9
HUMAN SPACE FLIGHT	10,234.1	2,010.0	1,939.7	1,862.8	1,796.2	1,743.3	1,719.0	1,531.6	2,312.5	25,149.2
SPACE STATION	10,113.1	1,939.2	1,889.6	1,833.6	1,782.0	1,742.0	1,719.0	1,531.6	2,312.5	24,862.6
DEVELOPMENT	9,190.1	1,918.2	1,752.4	1,612.8	1,409.2	1,184.3	837.7	566.8	326.2	18,797.7
UTILIZATION SUPPORT	175.21	21.0	28.3	67.9	86.9	95.1	106.3	111.9	204.2	721.6
OPERATIONS			108.9	152.9	285.9	462.6	775.0	852.9	1,782.1	4,420.3
OTHER	923.0									923.0
U.S./RUSSIAN COOPERATIVE PROGRAM	121.0	70.8	50.1	29.2	14.2	1.3				286.6
SCIENCE, AERONAUTICS & TECHNOLOGY		96.0	173.4	252.0	324.7	354.8	387.8	418.6	437.5	2,444.8
LIFE & MICROGRAVITY SCIENCES		96.0	158.4	210.8	262.2	298.4	331.9	360.7	387.5	2,105.9
SPACE STATION FACILITIES		37.0	90.5	137.3	184.2	210.4	226.2	228.7	262.5	1,376.8
LIFE SCIENCES		31.5	17.1	25.0	28.9	43.8	52.7	76.0	72.0	347.0
MICROGRAVITY RESEARCH		16.3	23.1	25.5	37.4	43.1	53.0	56.0	53.0	307.4
STS/SPACELAB MISSION MANAGEMENT		11.2	27.7	23.0	11.7	1.1				74.7
SPACE ACCESS AND TECHNOLOGY			15.0	37.1	52.6	51.3	52.8	53.7	50.0	312.5
MISSION TO PLANET EARTH (SAGE III)				4.1	9.9	5.1	3.1	4.2		26.4

Alternate Turbopump Development

Funding to begin development of an alternate design for the two turbopumps driving the Space Shuttle's Main Engine was initiated in FY 1987 The development of a new high-pressure oxygen turbopump and hydrogen fuel turbopump was undertaken to improve the safety, reliability, producibility. and maintainability of the current turbopumps. After an initial period of design and development, problems experienced in early development testing and accompanying increased costs resulted in suspension of the fuel turbopump's development, while development activities concentrated on the oxygen turbopump. Although further development problems were encountered with the oxygen turbopump, their successful resolution led to Congress agreeing in Spring 1994 to resumption of the fuel turbopump's development. The first flight of the oxygen turbopump will occur in 1995, followed two years later by the initial flight of the fuel pump. The budgetary estimates provided below include not only the funding required for the design, development, and extensive testing of these two turbopumps. but also the funding needed to produce the flight turbopumps for installation into the main engines for the four-orbiter fleet.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for NASA civil service workforce salary and expenses (S&E), and the use of government facilities and general and administrative support used to *carry* out the development. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	437.6	54.1	57.6	68.2	42.1	18.7	11.6	10.0		699.9
IMPLEMENTATION	20.2	11.9	40.6	56.5	65.1	50.5	38.5	19.8	27.4	330.5
TOTAL	457.8	66.0	98.2	124.7	107.2	69.2	50.1	29.8	27.4	1,030.4

Super Lightweight Tank

The design and development of a lighter external tank for the Space Shuttle was undertaken in 1993 after tests of new aluminum-lithium materials indicated that a significantly lighter external tank could be produced. The anticipated weight savings of approximately 8000 pounds would recover some of the ascent performance losses resulting from safety and reliability improvements instituted after the Challenger disaster. Coupled with other performance gains, the super lightweight tank will facilitate the Space Shuttle's operations at new higher inclination orbit established in 1993 for the international Space Station. The first launch of a Space Shuttle with the new tank is planned for the second half of 1997. In addition to the design and development costs, the figures below as "recurring cost" provide the estimate of the funding required for the external tank program's production of the new tanks. The estimates include the additional material cost which will be incurred in the production of subsequent tanks. The aluminum-lithium material is a specialty metal produced to rigorous specifications and accordingly costs more than the aluminum used at present.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for NASA civil service workforce salary and expenses (S&E), and the use of government facilities and general and administrative support used to carry out the development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT COST		50.8	39.6	32.7	30.4	11.7	1.6	.5		167.3
RECURRING COST		9.2	19.5	40.3	42.1	39.6	40.3	32.4	Continues	
TOTAL		60.0	59.1	73.0	72.5	51.3	41.9	32.9		390.7

Advanced X-Ray Astrophysics Facility

The design and development of the Advanced X-ray Astrophysics Facility (AXAF)was approved by Congress in the FY 1989 budget. The AXAF is the third of the four "Great Observatories" intended to observe the universe in four electromagnetic spectrum regions: visible, infrared, gamma ray, and x-ray. The initial phase of the AXAF's development was limited to a feasibility demonstration of the new mirror technology required to achieve the AXAF's objectives. A specially designed x-ray calibration facility was constructed to assure the mirrors meet their design specifications. The second phase was approved by Congress after the demonstration mirrors were successfully tested. In 1992, NASA management directed the restructuring of the AXAF program to reduce projected future funding requirements. A two-spacecraft approach was selected, a large imaging spacecraft (AXAF-Imaging) and a smaller spectroscopy spacecraft (AXAF-Spectroscopy). In 1993, Congress directed the elimination of the AXAF-S. The launch of the AXAF-I spacecraft is scheduled for September 1998 aboard the Space Shuttle, with an Inertial Upper Stage (IUS) providing delivery into a highly elliptical orbit around the Earth. The budgetary estimates provided below encompass: the early development of the mirror technology; the design and development phase: establishment of a mission-unique science center and preflight ground system development, followed by a five year period (1998-2002) of mission operations and science data analysis; the purchase of the IUS and integration activities: the average cost (including recurring costs for improvements and upgrades) of an FY 1998 Space Shuttle flight: mission-unique tracking and data support costs: and, the construction of the X-ray Calibration Facility.

The budgetary estimates provided below are the amounts included in the Human Space Flight for Space Shuttle flights and the Science, Aeronautics and Technology appropriations for the this program. They do not include the amounts being contributed by international participants, NASA civil service workforce salary and expenses (S&E), and the use of non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science/Physics and Astronomy section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
ADVANCED TECH DEVELOPMENT	54.2									54.2
DEVELOPMENT	480.2	239.3	234.3	237.6	187.3	93.7				1,472.4
MISSION OPS & DATA ANALYSIS	22.0	11.6	18.9	40.4	42.4	47.8	64.0	66.1	216.3	529.5
UPPER STAGE	8.2	6.9	15.2	18.3	19.1	9.6				77.3
FY 1998 SHUTTLE AVERAGE COST						476.5				476.5
TRACKING & DATA SUPPORT		.1	.2	.5	.4	.3	.2	.2	1.8	3.7
CONSTRUCTION OF FACILITIES	17.7									17.7
TOTAL	582.3	257.9	268.6	296.8	249.2	627.9	64.2	66.3	218.1	2,631.3

Relativity Mission/Gravity Probe-B

The development of the Gravity Probe-B mission began in 1993, after many years of studying mission design alternatives and developing the advanced technologies required for this mission to verify Einstein's theory of general relativity. The scheduled launch date is October 2000, using a Delta II launch vehicle. The development phase is currently underway, with award of the spacecraft development contract being made in 1994. The estimates provided below assume continuation of funding through the completion of the operational phase. It should be noted that the National Academy of Sciences has agreed to undertake a review of the scientific merits of the program: this review was triggered by questions raised within the science community as to relative value of the experimental approach given other developments in the field. The budgetary estimates below include funding for the experiment development activities initiated in 1993, 18 months of mission operations, and the launch services.

The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from FY 1985-87, but they do provide the amounts for the Shuttle Test of Relativity Experiment program initiated in FY 1988 and subsequently restructured into a ground test program only. The estimates also exclude: NASA civil service workforce salary and expenses (S&E), and the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science/Physics and Astronomy section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
STORE	125.5	2.4								127.9
DEVELOPMENT	1.9	40.0	50.0	51.5	53.0	53.7	56.3	36.8	7.8	351.0
MISSION OPS & DATA ANALYSIS									20.6	20.6
LAUNCH SUPPORT					.6	14.2	24.4	16.8	6.0	62.0
TRACKING & DATA SUPPORT										N/A
TOTAL	127.4	42.4	50.0	51.5	53.6	67.9	80.7	53.6	34.4	561.5

Global Geospace Science Missions

The development of the two Global Geospace Science (GGS) missions was approved by Congress in the budget for 1989. The Wind and Polar spacecraft are parts of a coordinated international science program to improve our understanding of the complex interactions between the sun and the Earth. Nineteen instruments aboard the two spacecraft will make measurements of the interaction between the solar wind with the Earth's magnetic field. The Wind spacecraft was successfully launched on a Delta II launch vehicle in November 1994. Final spacecraft integration and test activities are underway on the Polar spacecraft, as it heads for a launch in December 1995, also on a Delta II. The budgetary estimates provide for the experiment and spacecraft development, a three-year period of mission operations, the launch services, and unique tracking and data acquisition support required during the mission.

The budgetary estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts being contributed by international participants, NASA civil service workforce salary and expenses (S&E), and the use of non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science/Physics and Astronomy section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	385.1	27.6	40.0	5.4						458.1
MISSION OPS & DATA ANALYSIS	4.6	3.8	8.2	21.7	25.5	15.7				79.5
LAUNCH SUPPORT	110.2	2.7	9.2	3.0						125.1
TRACKING & DATA SUPPORT	20.6	4.0	1.6	1.3	.1					27.6
TOTAL	520.5	38.1	59.0	31.4	25.6	15.7				690.3

Collaborative Solar Terrestrial Research Program

The Collaborative Solar Terrestrial Research (COSTR) program is another key U.S. contribution to the international solar terrestrial research program. Beginning in FY 1987, funding provided for this program has enabled NASA to provide instruments and launch support for international spacecraft. In return. the U.S. obtains access to the science data collected by the five European Space Agency spacecraft and one Japanese spacecraft. The initial launch was carried out in July 1992 with the launch of the Japanese Geotail spacecraft on a U.S.-funded Delta 11. The October 1995 launch of the ESA Solar and Heliospheric Observatory (SOHO) will be on a U.S.-funded Atlas IIAS. Mission operations and data analysis provides for the operations support to the U.S. furnished instruments and the analysis of the scientific data gathered by them.

The budgetary estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts being contributed by international participants, NASA civil service workforce salary and expenses (S&E), and the use of non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science/Physics and Astronomy section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	274.9	32.8	23.2	3.8						334.7
MISSION OPS & DATA ANALYSIS	7.5	9.7	11.7	28.1	28.3	8.4				93.7
LAUNCH SUPPORT	102.4	43.0	31.0							176.4
TRACKING & DATA SUPPORT	28.9	5.3	4.8	2.2	1.4					42.6
TOTAL	413.7	90.8	70.7	34.1	29.7	8.4				647.4

The Explorer Development Program

The Explorer development program consists of small to mid-sized spacecraft conducting investigations in all space physics and astrophysics disciplines. The program provides for frequent, relatively low-cost missions to be undertaken as funding availability permits within an essentially level overall funding profile for the program. The funding profile provided below covers the design and development phase: other budget elements provide the related funding for launch services, mission-unique tracking and data acquisition support, mission operations and data analysis, and civil service workforce salary and expenses. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science/Physics and Astronomy section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
X-ray Timing Explorer	136.1	36.5	32.6							205.2
Advanced Composition Explorer		33.2	44.1	31.8	24.5	7.5				141.1
Small Explorers	117.9	39.4	33.1	37.9	40.2	43.9	44.9	46.1	continues	
Planning & Future Developments		14.2	15.1	55.3	69.8	91.1	101.7	104.9	continues	

X-ray Timing Explorer

Development on the X-ray Timing Explorer (XTE) began in FY 1990. The spacecraft is an in-house build at the Goddard Space Flight Center: instruments are being developed by the principal investigators. The XTE is scheduled for launch in August 1995 on a Delta II launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	136.1	36.5	32.6							205.2
MISSION OPS & DATA ANALYSIS			1.0	11.0	10.6	6.0	5.6			34.2
LAUNCH SUPPORT	11.5	20.8	14.9	4.0						51.2
TRACKING & DATA SUPPORT	3.8	4.3	4.7	1.8	.7					15.3
TOTAL	151.4	61.6	53.2	16.8	11.3	6.0	5.6			305.9

Advanced Composition Explorer

Development on the Advanced Composition Explorer (ACE) began in FY 1994. The spacecraft is being built by the John Hopkins Applied Physics Lab; instruments are being managed by the California Institute of Technology. The ACE is scheduled for launch in August 1997 on a Delta II launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT		33.2	44.1	31.8	24.5	7.5				141.1
MISSION OPS & DATA ANALYSIS					1.0	8.3	8.6	8.6		26.5
LAUNCH SUPPORT	.1	.8	11.5	24.0	19.1					55.5
TRACKING & DATA SUPPORT	.4	1.6	3.1	4.6	4.2	.8	.2			14.9
TOTAL	.5	35.6	58.7	60.4	48.8	16.6	8.8	8.6		238.0

Stratospheric Observatory for Infrared Astronomy

The initial development funding for the Stratospheric Observatory for Infrared Astronomy (SOFIA) is being requested in the FY 1996 budget. This new airborne observatory will provide a significant increase in scientific capabilities over the current Kuiper Airborne Observatory, which it would replace. The Kuiper is a Lockheed C-141A aircraft with 0.9 meter reflecting telescope, used to conduct scientific investigations at infrared and submillimeter wavelengths. The SOFIA would be accommodated in a Boeing 747 and would feature a 2.5 meter infrared telescope to be provided by the German Space Agency (DARA). If the program is approved for development, the initial operational date for SOFIA would be at the end of 2000. The budgetary estimates provided below do not include the preliminary design studies carried out in previous years or the funding contribution of the German Space Agency.

The budgetary estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts being contributed by the international participants, NASA civil service workforce salary and expenses, and the use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Suborbital program within the Space Science/Physics and Astronomy section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT				48.7	27.8	65.6	68.2	29.1		239.4
MISSION OPERATIONS								30.3	CONT.	CONT.

CASSINI

The Cassini mission will provide intensive, long term observations of Saturn's atmosphere, rings, magnetosphere and moons. The Huygens Probe will conduct direct physical and chemical analyses of the atmosphere of Saturn's moon, Titan. Cassini was approved as a new start by Congress in the FY 1990 budget. At the time it was initiated, a second spacecraft, the Comet Rendezvous and Asteroid Flyby (CRAF) was included. Congressionally-imposed reductions to FY 1992-93 funding requirements led to the termination of the CRAF mission and the deferral of the Cassini launch from April 1996 to October 1997. The Cassini program later underwent a significant redesign in early 1992 to reduce total program cost, mass and power requirements, while maintaining the October 1997 launch aboard a Titan N launch vehicle. After an extensive cruise phase, the spacecraft is scheduled to arrive at Saturn in 2004 and will begin a four year study of the Saturnian system. The program involves significant cooperation from international partners as well as U.S. government partners. The European Space Agency is providing the Huygens Probe and the Italian Space Agency is contributing the High Gain/Low Gain antenna for the spacecraft. There are twelve science instruments on the orbiter and six on the probe from international Principal Investigators. The Titan IV launch vehicle is being procured from the Department of Defense, and the Radioisotope Heater Units (RHUs) and Radioisotope Thermoelectric Generators (RTGs) are being procured by NASA from the Department of Energy.

The budgetary estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts being contributed by the international participants, NASA civil service workforce salary and expenses, and the use of government facilities and general and administrative support required to implement the program A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science/Planetary Exploration section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	588.2	266.6	255.0	191.5	107.3	13.8				1,422.4
MISSION OPS & DATA ANALYSIS						49.3	56.4	56.3	593.0	755.0
LAUNCH SUPPORT	33.0	86.4	78.1	98.9	115.3	40.0				451.7
TRACKING & DATA SUPPORT	15.8	.6	3.2	3.6	4.2	4.5	9.0	13.2		54.1
TOTAL	637.0	353.6	336.3	294.0	226.8	107.6	65.4	69.5	593.0	2,683.2

Discoverv Missions

Discovery missions are designed with focused science objectives that can be met with limited resources. Total development costs are not to exceed $150 million in constant FY 1992 dollars, and development schedules are limited to three years or less. There are two approved Discovery missions, the Mars Pathfinder and the Near Earth Asteroid Rendezvous. Future missions will be undertaken after selection through a peer review process.

The budgetary estimates provided below are the amounts included in the specific budget justification for this program within the Space Science/Planetary Exploration section in the Science, Aeronautics and Technology appropriation. Under the specific mission descriptions, see below, other direct program cost elements are included: the development of the spacecraft and experiments, one year of mission operations, the launch services, and unique tracking and data acquisition services. They do not include NASA civil service workforce salary and expenses, and the use of government facilities and general and administrative support required to implement the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
MARS PATHFINDER	60.8	77.5	35.9							174.2
NEAR EARTH ASTEROID RENDEZVOUS	66.6	52.2	31.3							150.1
FUTURE MISSIONS				36.6	80.0	115.3	125.2	123.0	Continues	

Mars Pathfinder

The Mars Pathfinder was approved as a new start in FY 1994 as one of the initial missions in the Discovery Program. The Mars Pathfinder mission will demonstrate the cruise, entry, descent, and landing system approach that will be used in future missions to place a network of small science landers on the Martian surface. Launch is scheduled for December 1996 on a Delta II expendable launch vehicle. The Mars Pathfinder is being conducted as an in-house effort at the Jet Propulsion Laboratory. Portions of the science instruments are being provided by Germany and Denmark.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT		60.8	77.5	35.9						174.2
MICROROVER	2.8	5.9	8.5	5.8	2.0					25.0
MISSION OPS & DATA ANALYSIS					9.7	5.9	2.0			17.6
LAUNCH SUPPORT	.3	9.6	19.0	18.5	4.9					52.3
TOTAL	3.1	76.3	105.0	60.2	16.6	5.9	2.0			269.1

Near-Earth Asteroid Rendezvous (NEAR)

The NEAR was approved as a new start in FY 1994 as one of the initial Discovery Program missions. The NEAR mission is being conducted as an in-house effort at the Applied Physics Laboratory, with many subcontracted subsystems. The NEAR spacecraft will conduct a comprehensive study of the near-Earth asteroid 433 EROS, including its physical and geological properties and its chemical and mineralogical composition. Launch of the NEAR spacecraft is scheduled for February 1996 on a Delta II launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT		66.6	52.2	31.3						150.1
MISSION OPS & DATA ANALYSIS				3.3	5.4	8.8	22.3	7.8		47.6
LAUNCH SUPPORT		24.6	15.9	11.2						51.7
TOTAL		91.2	68.1	45.8	5.4	8.8	22.3	7.8		249.4

Mars Surveyor Program

The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. The first mission in this program was approved as a new start in FY 1994. the Mars Global Surveyor mission. Future small missions are targeted for launch in the launch windows that occur approximately every two years.

The budgetary estimates below are the amounts indicated in the budget justification within the Space Science/Planetary Exploration section in the Science, Aeronautics and Technology appropriation. The specific write-up for the Mars Global Surveyor includes the amounts for the development of the spacecraft and instruments, two years of mission operations, and launch services. It does not include the NASA civil service workforce *salary* and expenses, the use of government facilities and general and administrative support used to *carry* out the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
MARS GLOBAL SURVEYOR		14.6	58.0	58.2	9.4					140.2
FUTURE MISSIONS			1.4	50.3	80.1	98.6	104.2	107.3	Continues	

Mars Global Surveyor

This mission will obtain a majority of the expected science return from the lost Mars Observer mission by flying a science payload comprised of spare Mars Observer instruments aboard a small, industry-developed spacecraft. Launch is planned for November 1996 on a Delta II launch vehicle. The funding estimates provided below do not include the previous expenditures of spare Mars Observer instruments or the amount recovered from the prime contractor after the Mars Observer untimely failure.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT		14.6	58.0	58.2	9.4					140.2
MISSION OPS & DATA ANALYSIS					16.6	19.8	20.8			57.2
LAUNCH SUPPORT			21.8	20.1	10.4					52.3
TOTAL		14.6	79.8	78.3	36.4	19.8	20.8			249.7

New Millennium Spacecraft

In this FY 1996 budget request. NASA has recommended approval of a new program to demonstrate how complex scientific spacecraft--such as those required for planetary missions--can be built for lower mission costs and to have short development times, while still possessing considerable scientific merit. The New Millennium Spacecraft program will enable the introduction of the latest technology advances into planetary spacecraft. The primary objectives of the program are to increase the performance capabilities of spacecraft and instruments while simultaneously reducing total costs of future science missions, thereby allowing more frequent flight opportunities even under the severe budget constraints of the future. In previous years, NASA and the Department of Defense have funded technology developments which offer extraordinary promise. This precursor work on technologies can now be demonstrated in a series of flight technology demonstration missions occurring at rate of one or more per year, with initial flights planned for the 1997-1998 timeframe.

The budgetary estimate below represents funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program, and funding is included for development and launch of one mission per year, tentatively beginning in the 1997-1998 timeframe. Launches are targeted for a small expendable launch vehicle. The budget estimate below does not include the NASA civil service workforce salary and expenses, the government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Planetary Exploration section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
ADVANCED TECHNOLOGY DEVELOPMENT			10.5							
DEVELOPMENT				30.0	30.0	50.0	50.0	50.0	continues	
LAUNCH SUPPORT					3.0	10.0	17.0	17.0	continues	
TOTAL			**10.5**	**30.0**	**33.0**	**60.0**	**67.0**	**67.0**		

Earth Observing Svstem

Before the Earth Observing System (EOS) was authorized in November 1990 in the FY 1991 budget as a new start, EOS planning had been in progress for over eight years. The EOS is key to achieving the objectives set forth in the Mission to Planet Earth program plan and the overall goal and scientific objectives of the interagency U.S. Global Change Research Program. EOS is an international science program, drawing upon the contributions of ESA, Canada, and Japan both in terms of spacecraft and instruments. This extraordinary collaboration is essential to reach the objective of providing long-term (15years), comprehensive measurements of the nature of global climate change.

At its outset, the EOS program was based on the flights of two series of large platforms, in addition to platforms from Japan and ESA and instruments carried on Space Station Freedom. Although EOS was understood to be a program having a 15-year period of flight operations, the initial estimates provided to Congress focused on the period through fiscal year 2000. The initial estimate of $18-2 1 billion included development, mission operations. data analysis, launch services, communications, construction of facilities and the amounts carried in the Space Station program for the polar platform's development. In the FY 1992 appropriations process, Congress directed NASA to modify the scope and cost of the program. The cost through FY 2000 was to be reduced by $5 billion, the FY 1993 funding level had to be reduced. and NASA was to examine the feasibility of using smaller platforms. In 1991, the program was restructured to employ five smaller flight series. In 1992. in response to the constrained budget environment, NASA further rescoped the program by Implementing a common spacecraft approach for all flights after the first morning series (AM- 1)spacecraft, increasing reliance on the cooperative efforts of international and other government agencies, and adopting a build-to-cost approach for the first unit of a multiple instrument build. The estimated NASA funding through FY 2000 was further reduced to $8.0 billion in this effort.

In the FY 1995 budget process, the program's cost estimate was further adjusted downward by approximately $0.9 billion, of which $0.3 billion reflected an accounting transfer for small business innovative research out of individual programs into a common NASA account, and $0.1 billion reflected the change to lower-cost launch vehicles. The further reductions in program funding were addressed in 1994 through a program rebaselining activity. A number of small spacecraft were introduced into the program's flight plans. In addition, alterations were made in flight phasing and accommodations were provided for a follow-on instrument to the enhanced thematic mapper being flown in 1998 on Landsat-7. Funding for the science investigations and data analysis was separated from the algorithms being developed to convert the instrument data into information. This change recognized the close relationship to similar science investigations and data analysis funded in the Mission to Planet Earth research and analysis account. (The amounts transferred are provided in the EOS science line in the table below.) In addition, it was decided to incorporate the development funding for the Landsat-7 into the EOS program in light of the integral ties between the two activities.

The budgetary estimate below are the amounts now included in the Science, Aeronautics and Technology appropriation for this program. The estimates also reflect the related program costs for Landsat-7's activities previously funded by the Department of Defense and planned for future funding by the Department of Commerce. They do not include the NASA civil service workforce

salary and expenses, the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. For comparability purposes, the estimates are provided only through FY 2000. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Mission to Planet Earth section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	TOTAL
MORNING SERIES (AM)	385.1	198.8	260.8	202.2	97.0	107.6	56.7	82.6	1,390.8
AFTERNOON SERIES (PM)	64.3	50.1	88.8	127.3	188.2	239.8	235.7	226.1	1,220.3
CHEMISTRY	9.6	2.2	10.3	27.7	82.1	107.4	147.5	182.0	568.8
SPECIAL SPACECRAFT	40.0	20.9	85.5	69.7	92.9	95.8	89.1	93.0	586.9
LANDSAT 7 DEVELOPMENT	32.5	74.1	87.4	78.8	56.1	48.8	8.0	1.6	387.3
ALGORITHM DEVELOPMENT	91.8	46.8	58.3	85.4	122.7	154.5	200.8	221.7	982.0
EOSDIS	244.4	188.2	230.6	289.8	309.8	291.9	317.4	358.7	2,230.8
SUBTOTAL	867.7	581.1	821.7	880.9	948.8	1,045.8	1,055.2	1,165.7	7,366.9
SPACE STATION PLATFORM	104.0								104.0
EOS SCIENCE	[60.0]	[17.7]	37.3	58.4	47.5	56.4	63.4	73.2	336.2
LAUNCH SERVICES	3.1	16.2	41.7	86.7	95.3	100.9	46.8	33.2	423.9
CONSTRUCTION OF FACILITIES	45.2	18.0	17.0	17.0					97.2
TRACKING & DATA SUPPORT				1.6	2.1	2.3	1.1	1.3	8.4
TOTAL	1,020.0	615.3	917.7	1,044.6	1,093.7	1,205.4	1,166.5	1,273.4	8,336.6

Earth Probes

The Earth Probes program consists of spacecraft and instrument developments to address specific, highly-focused mission requirements in Earth science research. They are complementary to the scientific data gathering activities carried out within the EOS program. The currently approved Earth probes are the Total Ozone Mapping Spectrometer (TOMS), NASA Scatterometer (NSCAT). and the Tropical Rainfall Measuring Mission. Future missions will be funded to take advantage of the new technologies in spacecraft and instrument design being developed by other federal agencies and by NASA in the Space Access and Technology program (Smallsat and the research and technology program) and program to develop New Millennium Spacecraft (funded in the Planetary program).

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program. The budget estimates immediately below do not include the estimated costs incurred by the international collaborators, mission operations and data analysis costs, launch services. related funding included in the Earth Observing System program, NASA civil service workforce salary and expenses, use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Mission to Planet Earth section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
SCATTEROMETER	174.3	17.1	15.4	3.9						210.7
TOTAL OZONE MAPPING SPECTROMETER.	74.5	13.8	14.9	8.5	6.4	11.8	7.	4.8		141.7
TROPICAL RAINFALL MEAS. MISS.	85.5	65.5	51.3	24.5	21.6					248.4
NEW TECHNOLOGY EARTH PROBES							50.0	50.0	continues	

Scatterometer

NASA began the development of the NASA Scatterometer (NSCAT) in October 1984 as a host instrument on the Navy Remote Sensing Satellite (N-ROSS). The N-ROSS program was canceled in March 1988. In August 1989, NSCAT was selected by the Japanese space agency for their planned Advanced Earth Observing System (ADEOS) mission. The instrument's design was altered to allow it to be accommodated on the ADEOS. The Japanese plan to launch the ADEOS spacecraft on their H-II launch vehicle in February 1996.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	174.3	17.1	15.4	3.9						210.7
MO & DA				6.2	9.3	6.8	3.1			25.4
TOTAL	**174.3**	**17.1**	**15.4**	**10.1**	**9.3**	**6.8**	**3.1**			**236.1**

Total Ozone Mapping Spectrometer

The TOMS Earth Probes program is a follow-on to the Total Ozone Mapper (TOM) instrument flown with such great success on the Nimbus-7 spacecraft from 1978 until just recently. A TOM instrument was also flown on the Russian METEOR spacecraft in 1991. The TOMS program consists of a set of instruments (flight models 3, 4, 5) and one small spacecraft being launched in mid-1995 on a Pegasus launch vehicle. Flight model 3 will be flown on this TOMS Earth Probe spacecraft. Flight model 4 is planned for launch on the Japanese ADEOS spacecraft in February 1996. Flight model 5 is currently planned for a cooperative mission with the Russian Space Agency in the year 2000.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	74.5	13.8	14.9	8.5	6.4	11.8	7.0	4.8		141.7
MO & DA	2.3	3.2	3.7	3.3	2.6	2.7	2.7	2.8	6.3	29.6
LAUNCH SUPPORT	15.8	.9								16.7
TRACKING (TOMS EARTH PROBE)	2.5	1.4	.5	.7						5.1
TOTAL	**95.1**	**19.3**	**19.1**	**12.5**	**9.0**	**14.5**	**9.7**	**7.6**	**6.3**	**193.1**

Tropical Rainfall Measuring Mission

The development of the Tropical Rainfall Measuring Mission (TRMM) began in FY 1992, after a four-year period of concept studies and preliminary mission definition. The TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. TRMM data will be useful to understand the ocean-atmosphere coupling, especially in the development of El Nino events, which form in the tropics but whose effects are felt globally. The observatory spacecraft is being built in-house at the Goddard Space Flight Center. The Japanese are building a critical instrument, the Precipitation Radar. Two other instruments are being developed with TRMM program funding, the Visible and Infrared Scanner and TRMM Microwave Imager. In 1992, two EOS-funded instruments were added to the payload, the Clouds and Earth's Radiant Energy System (CERES) and the Lightning Imaging Sensor (LIS). The budget estimates provided below include the costs of accommodating these two instruments on the TRMM observatory. The TRMM is currently planned for launch in August 1997 on the Japanese H-II launch vehicle. The EOS Data and Information System will have a specific capability for disseminating T'RMM data. The TRMM Science line provides the amounts funded in the research and analysis budget for science investigations.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT	85.5	65.5	51.3	24.5	21.6					248.4
EOS-FUNDED INSTRUMENTS/SCIENCE/DIS		[8.2]	[9.4]	[21.9]	[10.3]	[8.8]	[12.6]			[71.2]
MO &DA					4.9	25.7	29.1	29.4	38.6	127.7
SCIENCE	12.8	5.9	4.9	5.9	5.9					35.4
TRACKING & DATA SUPPORT	1.4	3.4	3.4	3.6	3.1	.9				15.8
TOTAL	99.7	74.8	59.6	34.0	35.5	26.6	29.1	29.4	38.6	427.3

Tracking and Data Relay Satellite Replacement Spacecraft Program

The Tracking and Data Relay Satellite (TDRS)Replacement Spacecraft program began in FY 1987 to replace the loss of a TDRS spacecraft aboard Challenger. The TDRS-7 is now in the latter stages of development and will result in the addition of a sixth functionally-identical, nearly design-identical spacecraft to the current constellation of TDRS. This spacecraft will help ensure continuation of Space Network operations in support of all compatible low-Earth orbital missions by maintaining the operational satellite system. Launch of the TDRS-7 is currently scheduled for the July 1995.

The budgetary estimates provided below cover the design and development phase and Shuttle launch costs. The Shuttle average launch cost has been used to indicate the launch support costs: the Shuttle program costs are included in the Human Space Flight appropriation. The spacecraft development and the launch services for the Inertial Upper Stage are now included under the Mission Support appropriation. The estimates do not include the NASA civil service workforce salary and expenses (S&E), and the use of government facilities and general and administrative support used to manage and support the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Office of Space Communications section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	TOTAL
SPACECRAFT DEVELOPMENT	342.1	5.7	22.2					370.0
LAUNCH SERVICES (IUS)	46.4	34.7	15.6					96.7
LAUNCH SUPPORT (STS)			469.6					469.6
TOTAL	388.5	40.4	507.4	0	0			936.3

TDRS Replenishment Spacecraft Program

As a result of reliability assessments which indicate that a sufficient number of TDRS may not be available by the end of the decade, the TDRS Replenishment Spacecraft program is being initiated. This program will provide for three additional TDRS spacecraft. Contract proposals for three additional TDRS spacecraft have been under review by NASA since the latter part of 1994. A firm fixed price contract award and initiation of development of these spacecraft is scheduled to occur in February 1995. Due to the high degree of sensitivity regarding this firm fixed price, commercial practices procurement, further details on the proposed design, capabilities, launch requirements, and other relevant issues are not available.

The budgetary estimates provided below covers the design, development and launch of three spacecraft and are included in the Missions Support appropriation. The estimates do not include the NASA civil service workforce salary and expenses (S&E) and the use of government facilities and general and administrative support used to carry out the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Office of Space Communications section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	Balance	TOTAL
DEVELOPMENT AND LAUNCH SERVICES		2.6	42.0	195.8	239.0	238.6	179.0	105.1	86.7	1,088.8
TOTAL		2.6	42.0	195.8	239.0	238.6	179.0	105.1	86.7	1,088.8

Second TDRS Ground Terminal/White Sands Ground Terminal Upgrade Program

The TDRS ground terminals are necessary for providing continuing, reliable Space Network capabilities required by all compatible low-Earth orbital missions. The Second TDRS Ground Terminal (STGT) Program was initiated in FY 1989. The new ground terminal will preclude the possibility of loss of the Space Network system by eliminating the single failure point of the original ground terminal at White Sands, New Mexico, which could result in a complete loss of communications. The STGT, Danzante. is the new ground terminal that was completed and approved for primary operations in December 1994. Upgrade of the White Sands Ground Terminal (WSGT), Cacique, is currently operating in a backup mode to Danzante and will begin its own refurbishment once Danzante has fully demonstrated stable support to all of its users. Danzante is expected to be operational by the end of FY 1995.

The budgetary estimates provided below are the amounts included in the Missions Support appropriation for this program. They do not include the NASA civil service workforce salary and expenses (S&E) and general and administrative support used to carry out the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Office of Space Communications section.

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	TOTAL
DEVELOPMENT	537.1	19.0	18.6	.2			574.9
COMMUNICATIONS	2.8						2.8
CONSTRUCTION OF FACILITIES	23.2						23.2
TOTAL	563.1	19.0	18.6	.2			600.9

Human Space Flight

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 1996 ESTIMATES

GENERAL STATEMENT

The Human Space Flight appropriation provides funding for NASA's human space flight activities. This includes the on-orbit infrastructure (Space Station and Spacelab), transportation capability (Space Shuttle program, including operations, program support and performance and safety upgrades), and the Russian Cooperation program, which includes the flight activities associated with the cooperative research flights to the Russian Mir Space Station. These activities are funded in the following budget line items:

Space Station: The Space Station will be an orbiting laboratory which will enable unique scientific and technological investigations in a microgravity environment and provide the essential understanding of the ability of humans to live and work in space for extended periods of time. Funding will support continued development of the Space Station, which was significantly redesigned in 1993 and now includes major participation by Russia.

U.S./Russian Cooperative Program: This program includes all flight activities in support of the joint space missions involving the Space Shuttle and the Russian Mir Space Station. This includes the Shuttle and Spacelab-unique requirements associated with Shuttle flights to Mir, as well as the funding for contractual services and supplies to be provided by Russia in conjunction with the joint Mir program and the international Space Station. Funding for experiments for the Mir flights is included in the Life and Microgravity Sciences and Applications and Space Station budgets.

Space Shuttle: This supports all the activities required for the continuing, safe operation of the Space Shuttle. This includes the hardware and support services to maintain the Shuttle launch schedule, and funding for activities to enhance the safety and performance of the Space Shuttle.

Payload Utilization and Operations: Funding is provided for the support of payloads flying on the Shuttle and Spacelab, as well as advanced technology projects and Engineering and Technical Base support for the field centers supporting Human Space Flight activities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT
FISCAL YEAR 1996 BUDGET ESTIMATES
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1994	1995	1996
HUMAN SPACE FLIGHT	**6,074.3**	**5,514.9**	**5,509.6**
SPACE STATION	1,939.2	1,889.6	1,833.6
RUSSIAN COOPERATION	170.8	150.1	129.2
SPACE SHUTTLE	3,558.7	3,155.1	3,231.8
PAYLOAD AND UTILIZATION OPERATIONS	405.6	320.1	315.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

HUMAN SPACE FLIGHT

For necessary expenses, not otherwise provided for, in the conduct and support of human apace flight research and development activities, including research; development; operations; services; maintenance; construction of facilities including repair, rehabilitation, and modification of real and personal property, and acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft; [$5,573,900,000] ***$5,509,600,000***, to remain available until September 30, [1996] ***1997. (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1995.)***

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT
REIMBURSABLE SUMMARY
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1994	1995	1996
HUMAN SPACE FLIGHT	61.2	105.4	109.5
SPACE STATION	0.8	0.2	1.3
SPACE SHUTTLE	30.5	48.3	49.6
PAYLOAD UTILIZATION AND OPERATIONS	29.9	56.9	58.6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1996 ESTIMATES

DISTRIBUTIONOF HUMAN SPACE FLIGHT BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Space Station Program Office	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Space Station	1994	1,939,200	392,000	1,071,400	57,000	221,300	0	0	0	1,300	132,200	0	200	63,800
	1995	1,889,600	333,100	1,394,000	81,200	48,400	0	0	0	900	17,600	0	0	14,400
	1996	1,833,600	349,000	1,307,100	73,000	81,700	0	0	0	100	8,700	0	0	14,000
U.S.-Russian Cooperative Program	1994	170,800	62,000	100,000	2,000	6,800	0	0	0	0	0	0	0	0
	1995	150,100	40,500	100,000	4,300	5,300	0	0	0	0	0	0	0	0
	1996	129,200	28,300	100,000	300	600	0	0	0	0	0	0	0	0
Space Shuttle	1994	3,558,700	1,033,900	0	929,400	1,520,000	37,100	0	5,700	0	0	300	100	32,200
	1995	3,155,097	869,500	0	835,000	1,351,597	49,400	0	6,100	0	0	0	0	43,500
	1996	3,231,800	959,700	0	808,800	1,378,100	44,000	0	5,600	0	0	0	0	35,600
Payload and Utilization Operations	1994	405,600	116,400	0	136,800	139,000	2,400	0	0	300	100	8,900	100	1,600
	1995	320,100	75,200	0	101,100	128,100	1,800	0	0	0	300	9,200	0	4,400
	1996	315,000	78,400	0	90,700	121,600	1,700	0	0	500	300	9,900	0	11,900
TOTALHUMANSPACE FLIGHT	1994	6,074,300	1,604,300	1,171,400	1,125,200	1,887,100	39,500	0	5,700	1,600	132,300	9,200	400	97,600
	1995	5,514,897	1,318,300	1,494,000	1,021,600	1,533,397	51,200	0	6,100	900	17,900	9,200	0	62.300
	1996	5,509,600	1,415,400	1,407,100	972,800	1,582,000	45,700	0	5,600	600	9,000	9,900	0	61,500

Space Station

HUMAN SPACE FLIGHT

FISCAL *YEAR* 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE STATION**

SUMMARY OF RESOURCES REQUI

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	Page Number
Development..	1,918,200	1,752,400	1,612,800	HSF 1-4
Utilization support	21.000	28.300	67,900	HSF 1-13
Operations..	--	108.900	152.900	HSF 1-16
Total	1,939,200	1.889.600	1.833.600	
Distribution of Program Amount bv Installation				
Johnson Space Center..	392,000	333.100	349.000	
Space Station Program Office	1,071,400	1,394,000	1,307,100	
Kennedy Space Center	57,000	81.200	73.000	
Marshall Space Flight Center	221,300	48,400	81.700	
Langley Research Center.	1,300	900	100	
Lewis Research Center	132,200	17.600	8,700	
Jet Propulsion Laboratory	200	--	--	
Headquarters..	63.800	14.400	14.000	
Total	1.939.200	1.889.600	1.833.600	

PROGRAM GOALS

The goal of the international Space Station is to provide a long-duration laboratory to allow investigations of the limits of human performance, vastly expand human experience in living and working in space, and provide the capability to understand whether there are additional opportunities for the large-scale commercial development of space. The experience and dramatic results

obtained from the use of the international Space Station, together with information obtained from robotic missions to the Moon, near-Earth asteroids, and Mars, will guide the future direction of the Human Exploration and Development of Space Enterprise, one of NASA's key strategic areas. The Space Station is key to NASA's ability to fulfill its mission to explore, use, and enable the development of space for human enterprise.

STRATEGY FOR ACHIEVING GOALS

The Space Station is unique because it will provide the world with a permanent outpost in space. The schedule for the current design emphasizes an early permanent crew capability that provides an advanced research laboratory for use by international crews for extended durations. Therefore. very early into the program, the Space Station will provide enormous benefits to stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge. In March of 1994, a Systems Design Review (SDR) was completed, which validated the current system design as meeting program requirements.

The international Space Station is the culmination of the redesign work begun in FY 1993 to increase efficiency and effectiveness in response to lower projections for the Agency budget and growing emphasis on other programs, such as science and aeronautics. Human presence in space is one of NASA's highest priorities, and the redesigned Space Station has met the President's goal to reduce program costs while still providing significant research capabilities. An entirely new management approach has been implemented, in which a single contractor (Boeing) has been given total prime and integration responsibilities. with the previous prime contractors (McDonnell Douglas, Rocketdyne. and Boeing Huntsville) serving as first-tier subcontractors to Boeing. This has produced clearer lines of authority and greater accountability. In addition, program management has relocated to a streamlined Space Station Program Office (SSPO) in Houston, structured around integrated product teams with responsibility for bringing the systems and elements into integrated launch packages. Project management organizations at the various centers have been eliminated. Efficiencies have been gained through these program management improvements, design changes, a simplified integration effort, and our recent invitation to the Russians to enter into the international partnership.

The Space Station will be developed within annual funding constraints of $2.1 billion, which includes not only the program described here, but also agreed-upon content for Space Shuttle-Mir activities, science payload facilities, and utilization related to the Space Station. Within NASA, extensive coordination with the user community is ongoing, with payload facilities and research and technology activities provided by the Office of Life and Microgravity Sciences and Applications, the Office of Space Access and Technology. and the Office of Mission to Planet Earth. These include the centrifuge and related facilities, furnaces, gloveboxes. various pieces of lab support equipment, solar dynamic flight experiment, and research and experiment development, and are funded in those programs' respective budgets. The current estimate for completing the development and assembly of the Space Station is $17.4 billion (from FY 1994 through June 2002). including $14.7 billion for developing and operating the Station, $0.2 billion for Space Shuttle-Mir activities. and $2.5 billion for science payload facilities and utilization. The total estimate and schedule is contingent upon annual funding levels of $2.1 billion for the activities described above. This funding level reflects the Agency commitment to Administration guidance, and is the minimum necessary to ensure the success of the program.

The Space Station's international aspect was initiated in 1984 with invitations for the full participation of other nations. President Clinton has expanded the international scope of the Space Station dramatically by forming a cooperation with the Russian Space Agency (RSA). Space Station team members include NASA, RSA. the Canadian Space Agency (CSA), the European Space Agency (ESA), and the National Space Development Agency of Japan (NASDA). The continued partnerships with the CSA, ESA, and NASDA significantly enhance the capabilities of the international Space Station, and ensure compatible development of interfacing elements. In accordance with the terms of our agreements, the U.S. and the international partners will share the total available resources and the common costs for operations. Currently, the CSA, ESA and NASDA have invested almost $4 billion for design and development, and anticipate a total expenditure of $8-9 billion. In accordance with the terms of the agreements, the U.S. and the international partners will share the total available resources and the common costs for operations. This unprecedented level of international cooperation could also serve as a model for cooperative activities in future space projects and enhance the feasibility of advanced initiatives.

Assembly of the Space Station will commence in 1997 at an inclination of 51.6 degrees in order to fully utilize Russian contributions as well as U S. and partner capabilities. The Space Station will support permanent 3-person crew operations in 1998. and evolve to a permanent 6-person crew by 2002. To ensure the earliest possible science and research activity, microgravity capability is planned for 1998. with the outfitting of the U.S. lab in December. With completion in June 2002, the Station will provide 110 kilowatts of electrical power (with 46 kW for users), 33 payload racks in the U.S. .ESA and NASDA laboratory modules, three Russian research modules, and an operational lifetime of approximately ten years.

BASIS OF FY 1996 FUNDING REQUIREMENT

SPACE STATION DEVELOPMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Flight hardware	1,609,700	1.319,900	1,277,200
Test, manufacturing and assembly	99,000	94,900	90.300
Operations capability and construction	151.000	169.800	137.100
Transportation support	58,500	117.600	83.000
Flight technology demonstrations	--	30.000	10.400
Subtotal	1,918,200	1,732,200	1,598,000
Operations capability and construction			
Neutral buoyancy laboratory - CofF	--	20.200	14.800
Total	1,918.200	1.752.400	1,612.800

PROGRAM GOALS

Development of the international Space Station will provide an on-orbit, habitable laboratory for science and research activities, including flight and test hardware and software, flight demonstrations for risk mitigation, ground operations capability and facility construction, shuttle hardware and integration for assembly and operation of the station, mission planning. and integration of Space Station systems.

STRATEGY FOR ACHIEVING GOALS

Space Station elements will be provided by the U.S. and our international partners. The U.S. elements include two nodes, a laboratory module, truss segments, four photovoltaic arrays, a habitation module, three pressurized mating adapters, a cupola, and an unpressurized logistics carrier. Various systems are also being developed by the U.S., including thermal control, life support. navigation and propulsion, command and data handling, power systems, and internal audio/video. The U.S. elements also include the FGB energy tug, being provided by a Russian firm under the Boeing prime contract, and a pressurized logistics module, similarly provided by Italy.

Canada, European nations, Japan, and Russia are also developing hardware for the international Space Station. Laboratory elements will be provided by the Japanese and European Space Agencies. Canada will provide the remote manipulator system,

vital for assembly of the station. The Russian Space Agency, invited to join the partnership, is providing experiment, power and service modules, Soyuz crew transfer vehicle, and one universal docking module (UDM).

Boeing has been awarded the prime contract for the Space Station, including integration responsibility. As a subcontractor to Boeing. McDonnell Douglas will develop and build the integrated truss segments that separate station elements and house essential systems, including central power distribution, thermal distribution and attitude control equipment. Radiators. communications antennas, photovoltaic (PV) elements and the Space Station Robotics Manipulator System are also mounted to truss segments.

All U.S. pressurized volumes are developed by Boeing Defense and Space Group. Missiles and Space Division in Huntsville, which is considered a first tier subcontractor to Boeing prime. After the first element launch in November 1997 of the FGB energy block, the next flight will launch Node 1, a pressurized volume which contains four radial and two axial berthing ports. The node will be launched with two Pressurized Mating Adapters (PMAs) attached and will serve as the docking location for the delivery of the U S. Laboratory Module and the pressurized logistics module. Node 2 with an attached cupola is manifested in the second phase of assembly. The final U.S. pressurized volume is the Habitation Module which will contain the galley, ward room, waste management, water processing and other crew support functions necessary for human operations.

The power system, essential to the station's housekeeping operations and scientific payloads, will be built by Rocketdyne Division, Rockwell International. in a subcontracted effort to Boeing. Four PV elements, containing a mast, alpha joint, radiator, arrays and associated power storage and conditioning elements make up the power system.

The development program also includes test, manufacturing and assembly support for critical NASA center activities and institutional support. Test capabilities, the provision of government furnished equipment (GFE), and engineering analysis provide in-line products to support the work of the prime contractor, its major subcontractors and NASA system engineering and integration efforts.

Operations capability provides the development of a set of facilities, systems and capabilities to conduct the operations of the Space Station. The work will be performed at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC). The KSC will develop launch site operations capabilities for conducting prelaunch and post-landing ground operations. The JSC will develop space systems operation capabilities for conducting training and on-orbit operations control of the Space Station. Construction of the Neutral Buoyancy Laboratory (NBL) in Houston will provide the capability for Space Station crew training to support a March 1997 training need date. Requirements for simultaneous extravehicular activity (EVA) training (up to nine crews at a time) and larger volume for time critical EVA tasks has dictated the NBL requirement. Although the FY 1995 budget planned for construction of the NBL on-site at the JSC, the FY 1996 budget requests authority to lease and subsequently purchase the Clear Lake Development Facility from McDonnell Douglas, including modification of the existing facility as an NBL.

The redesigned Space Station emphasizes multicenter and multiprogram cooperation. At JSC. a consolidated approach between Space Shuttle and Space Station will minimize, if not prevent, duplicated effort and costs for command and control and training. Crew training will be based on a detailed risk analysis to determine the optimum failure response training profile. Therefore,

training will be knowledge- and proficiency-based rather than driven by timeline and detailed procedures rehearsal. At KSC, investments in facilities will be limited. The redesigned Space Station will make efficient use of available personnel from other programs.

Transportation support provides those activities which are required to mate and integrate the Space Shuttle and Space Station systems. This budget line supports development and procurement of two external airlocks. and upgrade of a third airlock to full system capability. which are required both for docking the Space Shuttle with the Russian Mir and for use with the Space Station. Other items in this budget include: the Remote Manipulator System (RMS) and Space Shuttle Mission Training Facility upgrades; development of a UHF communications system and a laser sensor; procurement of an Operational Space Vision System: procurement of three docking mechanisms and Space Station docking rings; EVA/extravehicular mobility units (EMU) services and hardware; and integration costs to provide analyses and model development.

Space Station technology and system validation funding requirements include flight technology demonstrations in areas of joint NASA/RSA development that pose a level of technical or programmatic risk, warranting additional verification. Risk areas include life support, the data processing system, automatic rendezvous and docking, vibration isolation in a microgravity environment, assembly and maintenance, loads and dynamics, contamination, radiation environment. and micrometeoroid/orbital debris. In addition. funding is provided for operational techniques development for procedures, utilizing the Space Shuttle flights to the current Russian Mir. that will benefit the future operational phases of the Space Station program. A solar dynamic technology demonstration is being developed jointly with RSA for a mission to Mir, and is co-funded with the Office of Space Access and Technology.

MEASURES OF PERFORMANCE

Russian Elements Baselined - October 1993	Addition of Russian elements to "Alpha" design which came out of Space Station redesign activities during FY 1993.
Systems Requirements Review - December 1993	Programmatic and technical review to validate top level system requirements.
Contract Novation/Letter Contract With Boeing - February 1994	Established Boeing as single prime with integration responsibility, with former Space Station Freedom primes as first-tier subcontractors to Boeing.
Systems Design Review - March 1994	Technical review to validate that current system designs meet program requirements.
Agreement With Boeing - August 1994	"Not-to-exceed handshake agreement with Boeing prime for SDR baselined design.

Technical Convergence Review - November 1994	Technical review to assure that vehicle design baseline is consistent with engineering and contractual documentation, feasible with acceptable development risk, safe, operable and supports utilization.
Joint Program Review (Moscow) - November 1994	First in a series of top-level reviews of NASA-RSA cooperative effort; confirmed program milestones for 1995 and beyond.
Definitize Boeing Contract - January 1995	Finalization of NASA-Boeing agreement; establishes contractual baseline, cost and fee arrangement for Space Station.
Incremental Design Reviews - March 1995 (IDR-1) and 2nd Qtr FY 1996 (IDR-2)	Series of incremental, cumulative reviews throughout the design phase, which assure that system level requirements are properly implemented in the design, have traceability, and that hardware and software can be integrated to support staged assembly and operation. FY 1995 review will assess technical feasibility for the first six assembly flights, and forward planning review of all assembly flights.

Prime Development Activity

NOTE: All activities listed are planning milestones, and are not contractual.

Flight 1A: (November 1997) (First Element Launch) (Proton Launch Vehicle) FGB Energy Block	Self-powered. active vehicle: provides attitude control through early assembly stages; provides fuel storage capability after the service module is attached; provides rendezvous and docking capability Complete manufacture of structural components for first FGB flight article (3rd Qtr FY 1996) Complete subcontractor component deliveries to RSA for FGB assembly (3rd Qtr FY 1996) Complete manufacture of compartment that houses solar arrays on FGB (2nd Qtr FY 1996) Complete manufacture of the second of two solar panels for the FGB (3rd Qtr FY 1996) Complete and install solar arrays in FGB flight article (4th Qtr FY 1996)
Flight 2A: (December 1997) Node 1, Pressurized Mating Adapters (PMA-1, PMA-2)	Initial U.S. pressurized element, launched with PMA-1, PMA-2, and 2 stowage racks; PMA-1 provides the interfaces between U.S. and Russian elements; PMA-2 provides a Space Shuttle docking location Complete mechanical equipment installation into node structural test article (1st Qtr FY 1996) Complete node structural test article (STA) proof pressure/leak rate qualification testing (2nd Qtr FY 1996) Complete node structural test article (SA) static flight loads testing (4th Qtr FY 1996)

Begin engineering, fabrication, assembly, set-up and preparation for node STA modal survey test (3rd Qtr FY 1996)
Complete procurement of hardware for construction of Node 1 flight article (2nd Qtr FY 1996)
Complete welding for Node 1 flight article (FA) primary structure (3rd Qtr FY 1996)
Complete installation of mechanical equipment into Node 1 flight article primary structure (4th Qtr FY 1996)
Complete design and fabrication of Node 1 FA external secondary structure (e.g. multilayer insulation) (3rd Qtr FY 1996)
Begin final assembly and outfitting of all major components of Node 1 flight article (4th Qtr FY 1996)
Complete pressurized mating adapter (PMA-1) design (4th Qtr FY 1996)
Complete pressurized mating adapter (PMA-2) design (3rd Qtr FY 1996)

Flight 3A: (June 1998)
Z1 Truss Segment,
Control Moment Gyros (CMGs), PMA-3, KU-Band

Z1 Truss allows temporary installation of the P6 photovoltaic module to node 1 for early U.S. based power: KU-band and CMGs support early science capability: PMA-3 provides a Space Shuttle docking location for the lab installation on flight 5A
Complete Z1 truss Critical Design Review (3rd Qtr FY 1996)
Begin fabrication and assembly of Z1 truss (2nd Qtr FY 1996)
Complete design of control moment gyros (CMGs) (1st Qtr FY 1996)
Complete fabrication and assembly of CMG qualification unit (3rd Qtr FY 1996)
Begin build of CMG flight articles 1-4 (3rd Qtr FY 1996)
PMA-3 pressurized shell & secondary structure on-dock at McDonnell Douglas for tooling & fabrication (3rd Qtr FY 1996)

Flight 4A: (September 1998)
P6 Truss Segment,
Photovoltaic Array,
Thermal Control System (TCS) Radiators. S-Band

Establishes initial U.S. photovoltaic module based power capability: installed in a temporary location on top of the Z1 truss until flight 13A when it is permanently attached to the P5 truss: includes 2 TCS radiators for early active thermal control
Complete P6 truss segment (long spacer) qualification unit design (2nd Qtr FY 1996)
Begin fabrication and assembly of P6 truss segment qualification unit (4th Qtr FY 1996(
Complete assembly of integrated electronics assembly (IEA) qualification unit (1st Qtr FY 1996)
Complete mechanical installation and outfitting of IEA qualification unit (2nd Qtr FY 1996)
Complete IEA qualification unit hardware/software integration and functional testing (3rd Qtr FY 1996)
Begin thermal vacuum testing of IEA qualification unit

Flight 5A: (November 1998) U.S. Laboratory, 4 Lab System Racks	Establishes initial U.S. user capability; launches with 4 system racks preintegrated; KU-band and CMGs are activated Begin laboratory common module STA qualification testing (3rd Qtr FY 1996) Complete development of lab flight article pressure vessel (4th Qtr FY 1996)
Flight 6A: (December 1998) Mini-Pressurized Logistics Module (MPLM - Lab Outfitting). Canadian Remote Manipulator System, UHF	Adds U.S. lab outfitting with 1 stowage and 7 systems racks; UHF antenna provides space-to-space communication capability for U.S. based EVA, manifests Canadian SSRMS needed to perform assembly operations on later flights Complete MPLM-1 flight article structure procurement (2nd Qtr FY 1996) Complete fabrication of MPLM-1 qualification unit (1st Qtr FY 1996) Begin fabrication and assembly of MPLM-1 flight article (3rd Qtr FY 1996)

Non-Prime Development Activity

Global Positioning System	Provides autonomous, real-time determination of Space Station's position, velocity, and attitude of absolute time Complete Critical Design Review (4th Qtr FY 1996)
Crew Health Care System	Provides crew health care system hardware included in the health maintenance system, and the countermeasure system required to ensure crew health and safety Complete Critical Design Review (3rd Qtr FY 1996) Complete manufacture and assembly of qualification hardware (4th Qtr FY 1996)
Flight Crew Systems	Provides flight and training hardware and provisions for food and food packaging development: housekeeping management: portable breathing apparatus: commonality of decals and placards Complete Critical Design Review (tools/diagnostics/housekeeping) (1st Qtr FY 1996) Complete production of qualification hardware (tools/diagnostics/housekeeping) (3rd Qtr FY 1996) Complete test and verification of qualification hardware (tools/diagnostics) (4th Qtr FY 1996)
Joint Airlock Servicing And Performance Unit	Provides flight servicing, performance unit, and certification unit, Russian space suit support hardware interface definition and documentation, test plans and reports, mockups, and thermal analysis Complete Critical Design Review (2nd Qtr FY 1996) Certification unit hardware delivered to Airlock Test Article (2nd Qtr FY 1996)

Station Training Facility (STF)	Primary facility for space systems operations training and procedures verification Part task trainer ready for Flight 1A (4th Qtr FY 1996) Achieve Mission Control Center (MCC)/STF integrated operations capability (3rd Qtr FY 1996)
Integrated Planning	Provides planning and analysis tools for pre-increment and real-time operations systems (IPS) supporting trajectory/flight design, timelines, resource utilization, onboard systems, performance analyses systems operation data file procedures and control, maintenance operations. inventory and logistics planning, robotics analysis, procedures development Achieve First Element Launch capability (2nd Qtr FY 1996)
Mission Control Center	Facility providing integrated command and control capabilities and support to real-time increment operations Achieve capability for: ascent/entry; full Mir command/telemetry support: data record/playback; initial voice record/playback (3rd Qtr FY 1996)
Neutral Buoyancy Laboratory (NBL)	Provides training tank facility for neutral buoyancy training capability; current planning is to initially lease and subsequently acquire the Clear Lake Development Facility to house the NBL Complete training tank construction (3rd Qtr FY 1996) Joint occupancy for NASA outfitting (4th Qtr FY 1996)

ACCOMPLISHMENTS AND P ANS

During FY 1994. the contractual arrangement with the three former prime contractors was realigned to create a single prime (Boeing). with full integration responsibility. Subsequently, a major effort was devoted to implementation of this new management scheme. A Request for Proposal (RFP) was released, based on the technical program baselined at the System Design Review in March 1994. and Boeing submitted a $7.4 billion proposal. Extensive fact-finding activities were carried out with Boeing and each of the first tier subcontractors (McDonnell Douglas, Rocketdyne. and Boeing Huntsville). Adjustments were made in program content and development approach, followed by contract negotiations with Boeing prime. On August 31, a $6.2 billion "not-to-exceed' handshake agreement was reached, and the contract definitization process has been underway since that time. A final contract was signed January 13. 1995.

In concert with this activity, the Space Station Program Office was staffed in Houston, with newly defined teams. functions, and interfaces. Additionally, Utilization and Research Officeswere formally established, to ensure user participation in all aspects of station planning and development.

Additional contractual activity included:

- Definitization of a contract with the Russian Space Agency
- Entry into a contract with Lockheed for procurement of the Russian-built FGB
- Award of contract to Rockwell for Space Shuttle external airlocks and modification kits

These contractual activities are a reflection of the program changes related to incorporation of extensive Russian involvement in the international Space Station. In FY 1994. a three phase program was formulated and negotiated with the Russians, to provide early research through utilization of the existing Mir Space Station (Phase I); early microgravity capability on the international Space Station using a combination of U.S., Canadian and Russian provided hardware (Phase II); assembly and operation of a six person permanently staffed research facility, with full international participation (Phase III). During FY 1994 the technical configuration and requirements were established to accommodate Russian hardware and placement of the Space Station in a 51.6 degree orbit. Study of, and modifications to U.S. elements and systems have been necessary to assure integration of hardware not originally designed for a 51.6 degree inclination or Russian interfaces.

As a result of these changes, the program baselined a station configuration in the System Requirements Review, including a fourth photovoltaic array. The assembly sequence was adjusted to reduce risk and provide early U.S. power. A Program Execution Plan was put into place, and a Vehicle Architecture Review conducted, to assure that any cost reduction activities had no adverse effects on the technical design.

Design, development and testing of hardware continued through FY 1994. including successful thermal vacuum testing of the beta gimbal assembly: completion of the first hatch subassembly; and welding of the aft cylinder common module structural test article, as well as the node structural test article bulkhead and radial docking port. The first of two extravehicular activity mobility units were shipped from Hamilton Standard to the Johnson Space Center (JSC). In addition. construction was completed on the Space Station Processing Facility at the Kennedy Space Center (KSC).

Activity in FY 1995 will result in a definitized contract with Boeing prime. followed by an Incremental Design Review (IDR) in the second quarter. Negotiations will be completed with the Russian supplier of the FGB energy core in order to support the First Element Launch. Development of the payload training capability at the JSC and physical integration capability at the KSC will be completed, in addition to the design of payload ground systems and facilities. Node 1 qualification testing will start, and manufacture of the Node 1 flight article is scheduled to begin. The laboratory engineering development article (EDA) will be completed, as will fabrication of the Space Station Airlock Test Article (SSATA). Construction is planned to begin on the Neutral Buoyancy Laboratory, and delivery of docking module hardware is scheduled (mockups, experimental test unit and flight unit).

In FY 1996, effort will continue to press toward First Element Launch in November 1997. Manufacture and testing of flight hardware, preparation of operational capability, and construction of facilities will highlight development activities during the fiscal year. As evidenced by the milestones listed in the Measures of Performance section, final fabrication and testing of flight hardware will be the focus, in order to meet the demands of the early assembly and utilization missions. The first six U.S. flights referenced in that section complete Phase 2 of the three-phase program and establish the initial U.S. research capability for the utilization flights that will begin in the second quarter of FY 1999.

BASIS OF FY 1996 FUNDING REQUIREMENT

UTILIZATION SUPPORT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
User support	21,000	28,300	67.900

PROGRAM GOALS

Utilization support provides and operates the Payload Operations Integration Center (POIC)/United States Operations Center (USOC)user support facilities and the systems and capabilities necessary for user operations. Following development of facilities and capabilities, utilization support will integrate user support and conduct user operations across NASA centers and with the international partners. Using Marshall Space Flight Center's (MSFC)existing capability, utilization support will provide streamlined and responsive payload operations support to users through a consolidated research and science control facility.

STRATEGY FOR ACHIEVING GOALS

Consolidated utilization includes development of a payload operations integration capability and the Payload Training Complex as well as extensive payload mission planning, analytical integration, and the Payload Data Servicing System (PDSS). The MSFC's unique express rack program provides an efficient payload integration capability for smaller payloads that require a limited amount of resources. User support also includes outreach, express pallet program, and support equipment.

User operations encompasses the payload functions from the initial definition of the payload for flight through the onboard operation and return of the data to the user. Funding is provided for payload planning, development of operations documentation, training of the flight and ground teams and the execution of each mission to meet the needs of the users.

For the redesigned Space Station. the payload integration process has been streamlined and shortened significantly. Standardized payload accommodations and an express rack concept have been adopted to allow for later payload manifesting. Real-time support has also been reduced, based on a flexible planning concept that allows for activity scheduling during the mission.

The POIC and USOC are located in the MSFC Huntsville Operations Support Center (HOSC)to aid in the streamlined payload process. Space Station unique capabilities will augment the capabilities of the infrastructure which shall also provide support to Space Shuttle/Spacelab missions and the Advanced X-ray Astrophysics Facility. Services and capabilities provided within the POIC/USOC shall include: communications, voice services, video services, data system services, and actual user facilities.

Many of the functions of payload integration benefit the international partners. Payload integration, training, and the POIC operations are all functions provided by the U.S. that are necessary for payloads to be integrated at the stationwide level.

MEASURES OF E

Complete Systems Requirements Definition for Payload Data Servicing System (PDSS)- 2nd Qtr FY 1994	The PDSS provides the data handling software and network needed to distribute data from the Tracking and Data Relay Satellite System (TDRSS) to users at the POIC/USOC and other remote systems.
Complete Operations Concept for Space Shuttle/Space Station operations in the HOSC - April 1994	Performing payload operations for Space Shuttle and Space Station in the same facility allows for more efficient and cost effective payload operations.
First TASP unit delivery - 3rd QTR FY 1995	Test & Simulation Processor (TASP) is used to verify the PDSS software in a real-time flight simulated environment.
Complete Phase 1 & 2 of the POIC/USOC integrated systems - 3rd Qtr FY 1995 (Final Phase 5 complete 1st Qtr FY 1998)	POIC/USOC systems provide real-time support to Space Station payloads including: communication, voice, video, data systems, and facility services.
Complete PDSS Integration & Test - 4th Qtr FY 1996	The PDSS provides the data handling software and network needed to distribute data from the TDRSS users at the POIC/USOC and other remote facilities.
Receive first of four increments for (PIMS) - 2nd Qtr FY 1996 (Final build - 3rd Qtr FY 1998)	Payload Information Management System (PIMS) provides online data system elements for reception. system (PIMS) software code/test recording and distribution of telemetry data to users and verification consoles and remote user facilities.
Complete front end processor build - 3rd Qtr FY 1996	The front end processor unit is a key element in the reception of data from TDRSS. It converts high rate data into usable low rate data.

COMPLISHMEN AND PLANS

FY 1994 marked the formal establishment of the Utilization Office. Early in the process the Payload and Research Requirements were updated and implemented in the international Space Station program. Additionally in FY 1994 the EXPRESS rack, which provides standard power and data communications interfaces for payloads, was transferred into flight hardware development and the ESA distributed operations concept was baselined. The PDSS completed its system and detailed requirements definition and the POIC/USOC had completed preliminary system design and development.

During FY 1995 PDSS development will continue with the first Test and Simulation Processor unit delivery in the 3rd quarter. The POIC/USOC integrated system, which will be completed in five phases will complete phase I and phase II of development. Also in FY 1995, increment operations preparations and payload analytical integration began for the first utilization flights.

Completion of the payload ground system and facilities design is planned for FY 1996. As indicated in the Measures of Performance section above, activities begin to focus more on integration and test. Key activities include qualification, fabrication and delivery of an EXPRESS rack to be flown on the Microgravity Science Lab. Development and design of the payload training capability at the Johnson Space Center (JSC) and physical integration capability at the Kennedy Space Center (KSC) will be completed during FY 1996. The PDSS design and development will be completed and integration and testing will begin. Phase III and IV of the POIC/USOC system will be completed.

BASIS OF FY 1996 FUNDING REQUIREMENT

SPACE STATION OPERATIONS

	FY 1994	FY 1995	FY 1996
		Thousands of Dollars)	
Vehicle operations	--	40,100	50,800
Ground and transportation operations	--	68.800	102.100
To	--	108,900	152,900

PROGRAM GOALS

The first objective of the operations program is to provide for the safe, reliable, and sustained operation of the Space Station and the ground and transportation operations required to support the vehicle. The second major goal is to perform the operations in a simplified and affordable manner. Space Station operations will rely on the infrastructure developed for the Space Shuttle and the experience derived from the Space Shuttle-Mir program to develop efficient and effective operations. Finally, operations will facilitate the transition of the various elements of development to the operations program.

STRATEGY FOR ACHIEVING GOALS

In order to increase the efficiency and lower the cost of operations, Vehicle Operations and Ground and Transportation operations planning will begin early in development.

Vehicle operations will provide: post-development systems engineering and integration to sustain the specification performance and reliability of Space Station systems: logistics support for flight hardware and launch site ground support equipment: and configuration management and any associated procurement activity.

Vehicle operations sustaining engineering will be performed by a small cadre of civil service system experts located at each development center, as opposed to carryover of prime contractor and subcontractor personnel. Additionally, flight software sustaining engineering will be consolidated at the Johnson Space Center (JSC) to allow all flight software to be handled under a single contract.

Maintenance and repair costs have been minimized on the redesigned Space Station by accepting longer repair time spans, establishing a single maintenance and repair capability at the Kennedy Space Center (KSC) and using original equipment manufacturers or other certified industry repair resources.

Ground operations will provide command and control, training, operations support and launch site processing. A unified command and control center for the Space Station composed of the Mission Control Center-Houston (MCC-H)and the Mission Control Center (MCC)-Kaliningrad. The MCC-H will be the prime site for the planning and execution of integrated system operations of the Space Station, with exclusive command and control authority. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite System (TDRSS)system.

Flight controllers will be trained to operate the Space Station as a single integrated vehicle, with full systems capability in the training environment. Crew members will be trained in Space Station systems, operations. and other activities expected during a mission. Part-task and full hardware mockups and simulators will be used to provide adequate training for the crew prior to flight. Integrated training, consolidation of training facilities and the concept of proficiency based learning will increase the efficiency of the overall training effort.

Operations support will provide analysis supporting systems definition. development, and implementation to ensure a safe and operationally viable vehicle is delivered and can be maintained. Functions include the following: vehicle design participation and assessment, operations product development, ground facility requirements and test support, ground display and limited applications development, resource planning, crew systems and maintenance, extravehicular activity (EVA) and photo/TV training, operations safety assessments, medical operations tasks, mission execution and systems performance assessment, and sustaining engineering.

Launch site processing will begin at the KSC after the flight cargo elements have undergone acceptance testing at the development location. Processing includes integrated testing. interface verification, servicing, launch activities and experiment-to-rackphysical integration. Because Space Station is a ten-year operational program, no major upgrades to facility systems and equipment *are* being planned.

MEASURES OF PERFORMANCE

Issue first multi-increment manifest - December 1995	Provides the basis for all planning of assembly and utilization flights.
Publish FY 1996 operations summary - June 1995	A comprehensive plan for all operations activities necessary to support the Space Station first element launch (FEL)and follow-on flights.
Baseline bilateral NASA-RSA Operations Implementation Plan - August 1995	Details the roles and responsibilities NASA and RSA will perform during Space Station operations.
Complete Integrated Planning System for First Element Launch - March 1996	The specific software that enables on time delivery of the initial station element at KSC.

Complete MCC-H/SSTF Integrated Operations Training Capability - May 1996	Supports the training schedule required to train ground crews for real-time operations of the Space Station Vehicle.
Part Task training capability for U.S. flights 1A to 4A - July 1996	Required 18 months prior to flight for real-time operations training.
Demonstrate MCC-H full Mir command and telemetry support capability - July 1996	Real-time validation of the MCC-H command and telemetry capability necessary for the support of the Space Station flight vehicle.

ACCOMPLISHMENTS AND PLANS

Although no operations funding was expended in FY 1994. the Space Station OperaUons Program Office was established. Teams. functions and interfaces were defined. A basic concept for operations was developed based on the NASA Operations Phase Assessment Team and the Concept of Operations and Utilization (COU), which is the formal document that provides top level source information on how International Space Station operates, was baselined with all partners except Russia. Negotiations regarding Space Station command and control with the Russians were begun.

At the beginning of FY 1995. the Phase I operations strategy was completed. Throughout the fiscal year operations will provide support to station design and development teams to ensure safe and cost-effective operability of the Space Station. The MCC-H will provide support to the May 1995 docking mission to Mir in the special vehicle operations room. The Space Station Training Facility (SSTF) will have almost complete capability for full and part-task training. It will be able to provide full-up MCC-H flight controller training and integrated ground crew training. Logistics and maintenance activities include provision of vehicle design evaluation in conjunction with the IDR-1 to ensure supportability during the operational time frame. Spares requirements and maintenance procedures will also be developed.

In FY 1996, funding will support the MCC-H with ascent/entry capability, full Mir command and telemetry support capability, and data/voice record and playback capability. The integrated planning system will begin planning for first element launch and the SSTF will also begin part task training for the U.S. lab. Before the end of FY 1996, the MCC-H and the SSTF will begin Integrated Operations Training which will provide crucial training for real-time Space Station operations. Supply support, transportation support, and site facilities support infrastructure required for spaces and repairs will be provided in preparation of major buys that will begin in FY 1997. Additionally, long lead spare items such as electronic, and electro-mechanical (EEE) parts will be purchased to support orbital replaceable unit (ORU) spares.

US/Russian
Cooperative
Program

HUMAN **SPACE FLIGHT**

FISCAL *YEAR* 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **U.S./RUSSIAN COOPERATIVE PROGRAM**

SUMMARY OF RESOURCES RE

	FY 1994	FY 1995	FY 1996	Page Number
		(Thousands of Dollars)		
Russian space agency contract support	100.000	100.000	100,000	HSF 2-1
Mir support	70.800	50.100	29.200	HSF 2-1
Total	170.800	150.100	129.200	
Distribution of Program Amount bv Installation				
Johnson Space Center	62,000	40.500	28,300	
Space Station Program Office	100,000	100,000	100,000	
Kennedy Space Center	2.000	4,300	300	
Marshall Space Flight Center	6.800	5.300	600	
Total	170.800	150.100	129.200	

PROGRAM GOALS

The United States and the Russian federation have begun a joint cooperative space program to accomplish six major goals. First, the program will permit us to develop, maintain, and enhance capabilities and operations to allow humans to live and work continuously in space. Second, by establishing a relationship with Russia as an international partner for the human exploration and exploitation of space, the United States can reduce the cost of future U.S. space initiatives by applying Russian-developed technology. Third, by flying Space Shuttle missions to the Russian Mir. the United States can enhance its understanding of long-duration operations, along with life sciences and microgravity research benefits from long-duration experimentation. Fourth. early cooperation with the Russians will permit us to develop common systems and operating procedures which will increase the probability of success and mitigate risks in the design, assembly, and operation of the international Space Station in which they

are a full partner. Fifth, by engaging Russia in constructive space work, the United States can advance its foreign policy initiatives. Finally, this relationship between the U.S. and Russian space agencies will advance U.S. national space programs as well as U.S. aerospace industry.

STRATEGY FOR ING GOALS

The two major activities comprising the U.S./Russian cooperative program include conducting joint space activities with Russia with the Mir space station and the contract with the Russian Space Agency (RSA) which will provide services and hardware for Phase I and Phase II of the Space Station program.

Parts of Phase I and Phase II are conducted in parallel. Phase I expands the joint participation by U.S. and Russian crews in Mir and Space Shuttle operations. This expanded program uses the unique capabilities of the Space Shuttle and the Mir and provides the potential for up to ten flights to Mir. including U.S. crew stays aboard Mir. Current NASA planning manifests seven Space Shuttle flights to Mir. This program will provide valuable experience and test data that will greatly reduce technical risks associated with the construction and operation of the international Space Station and provide early opportunities for extended scientific and research activities. Mir capabilities will be enhanced by contributions from both countries. The Space Shuttle will bring new solar arrays. which will be built by the Russians. using solar cells provided by the U.S. which will replace existing arrays on Mir. Russia will add Spektr and Priroda modules to Mir. equipped with U.S. and Russian scientific hardware to support science and research experiments.

Phase II combines U.S. and Russian hardware to create an advanced orbital research facility with early human-tended capability. This facility will expand significantly the scientific and research activities initiated in Phase I, and will form the core of the international Space Station. Phase II also develops the systems capabilities, support, and other infrastructure to complete the international Space Station.

Russian Space Agency Contract Support

Under a fixed-price contractual arrangement with NASA, the RSA will furnish supplies and/or services to enhance Mir operational capabilities, perform joint space flights, and conduct joint activities to design, develop, operate, and use the Space Station.

During Phase I. which encompasses those activities related to the Space Shuttle flights to Mir, the RSA will provide management, Mir lifetime extension, Mir capabilities expansion, docking hardware and mission support for both long-duration and short-term missions. Management activities include project documentation, and program and subcontract management. Mir lifetime extension includes system requirements planning, communication and control systems analyses and upgrades, ground control facilities, thermal control documentation and requirements definition. environmentally-closed life support system (ECLSS) upgrades, power supply system upgrades, propulsion systems documentation and initial design and test, and elements of construction and mechanisms. To expand Mir capabilities. Spektr and Priroda modules will be attached to the Mir for scientific use by Russia and the U.S.

Phase II combines U.S. and Russian hardware creating an advanced orbital research facility which enables early permanent human presence. This facility forms the core of the international Space Station. During this phase, the RSA will provide management, advanced technology, international Space Station elements, and an evaluation of using the Proton launch vehicle with a transfer vehicle such as the Russian-built Space Tug as a back-up to Space Shuttle. Advanced technology includes joint development of ECLSS upgrades and a study to develop a common space suit. International Space Station elements include requirements definition of a joint airlock and androgynous peripheral docking system (APDS) hardware, service module modifications, FGB energy block modifications, and a study on a scientific power platform.

Mir Support

Successful execution of Space Shuttle flights to the Russian Mir space station will pave the way for Russian participation in the U.S.-led international Space Station. From mid-FY 1995 through late FY 1997. NASA will fly seven missions to the Mir with the potential of up to three additional flights. The primary objectives of these flights are to rendezvous and dock with the Mir, perform on-orbit joint U.S./Russian life sciences and microgravity investigations, resupply Mir logistics, and provide crew exchange. The first of these flights will employ a Spacelab long module to support experiment transport and operation, as well as the transport of Mir hardware. Four other flights will require pressurized habitable modules to transport Russian logistics items, NASA and Russian science and technology payloads, and international Space Station risk mitigation payloads to Mir. These modules will be supplied by Spacehab. Inc.

By its very nature, the U.S./Russian Cooperative program relies on support from the Russian government and Russian industry to be successful. The Russian government is making a substantial effort in the success of this mission by providing access to their Mir Space Station, providing training for our astronauts, and working with NASA to develop joint operational procedures. By contributing their expertise in long-duration missions gained through many years of Mir operations. and assisting NASA in the development and test of procedures used to rendezvous and dock with the Mir, they are strengthening NASA's ability to assemble safely and efficiently, operate and use the Space Station. Under the aegis of the contract with NASA, the RSA will loan several items for use during Phase I. These items include two Russian solar panels, a solar panel frame prototype, solar array ground support equipment (GSE), docking mechanism GSE and short-term mission crew training mockups. During Phase II, the RSA will loan two space suit servicing and support equipment sets.

Major contractors involved in the U.S./Russian Cooperative program include the RSA. the RSC-Energia, Krunichev, the Gagarin Cosmonaut Training Center, Rockwell International. and Spacehab. Inc.

MEASURES OF PERFORMANCE

For this cooperative program, the level of performance will be measured by clearly defined, discrete results including successful docking and undocking of the Space Shuttle and Mir. successful joint operations between the Space Shuttle and Mir, exchange of crew, and delivery of both pressurized and unpressurized cargo. The success of the extensive science program will be measured by accomplishing many detailed test objectives, and the post-mission analysis of the science data. However, the most important and meaningful indicator of success will be completing a joint mission with our Russian partners. demonstrating our ability to work

together in space safely and effectively, and laying the foundation for the unprecedented scope of our joint endeavor in building and operating the international Space Station.

The following events represent significant milestones in the successful completion of the U.S.- Russian Cooperative program:

Russian Space Agency Contract Support:

Delivery of hardware for U.S. experiments on Spektr - 1st Qtr FY 1995	Design, fabrication, and test of hardware for Spektr launch of U.S. experiments
Delivery of docking mechanism 3rd Qtr FY 1995	Docking mechanism to support flights to Mir
Delivery of hardware for U.S. experiments on Priroda - 4th Qtr FY 1995	Design, fabrication, test and installation of hardware for Priroda launch with U.S. experiments
Launch of U.S. experiments on Priroda - 4th Qtr FY 1995	Priroda launch will carry additional U.S. science and equipment
Delivery of airlock depress/ repress pump assembly - 3rd Qtr FY 1996	Delivery of flight article
Delivery of passive docking mechanisms - 3rd and 4th Qtrs FY 1996	Delivery of three passive docking mechanisms, associated avionics, control panels and documentation to support Phase II Space Shuttle flights to the international Space Station
Delivery of docking mechanisms 2nd. 3rd. and 4th Qtr FY 1997 and 1st Qtr FY 1998	Delivery of four docking mechanisms for Space Shuttle flights to Space Station with three sets of associated avionics

Mir Support:

Progress launch to Mir - 2nd Qtr FY 1995	Progress launch to Mir will carry U.S. science experiments

Astronaut launch on Soyuz - 2nd Qtr FY 1995	American astronaut will be launched on Soyuz to perform science investigations
Spektr module launch to Mir - 3rd Qtr FY 1995	Spektr launch will carry additional U.S. science experiments and equipment
Space Shuttle docking to Mir - 3rd Qtr FY 1995	STS-71 rendezvous and first docking flight to Mir with crew exchange
Complete Spacehab primary structure - 4th Qtr FY 1995	Spacehab. Inc. will complete manufacture of the primary structure for use on STS-76 and STS-79
Docking module delivery to Mir - 1st Qtr FY 1996	STS-74 will deliver a new docking module to Mir allowing the Space Shuttle to dock to a more favorable port
Joint EVA spacewalk on Mir - 4th Qtr FY 1996	Perform a joint U.S./Russian spacewalk to validate and demonstrate assembly techniques for the international Space Station

ACCOMPLISHMENTS AND PLANS

Russian Space Agency Contract Support

NASA and the RSA definitized their contract in June 1994. During FY 1994, the RSA achieved 47 milestones. These deliverables included the solar dynamics data package, the FGB energy block procurement plan and long-lead procurement plan, flight array fabrication (stage 1).and stage 1 tooling for the manufacturing of the docking module. Deliverables anticipated in FY 1995 include the FGB energy block structural mockup, photovoltaic arrays with associated frames, cabling, and deploy/attach mechanisms, the docking module flight unit. the docking module electrical mockup. the docking module weightless environment training facility (WETF) mockup, the docking module experimental test unit, and the docking mechanism for Space Shuttle flights to Mir. In FY 1996, the RSA or its subcontractors will deliver the solar dynamics qualification carrier and instrument module, the solar dynamics module qualification unit, and the solar dynamics verification GSE including training hardware. In addition, NASA will receive three passive docking mechanisms.

Mir Support

In preparation for STS-71 in May 1995, in which the Space Shuttle Atlantis (OV-104)will dock with the Mir, qualification testing for the external airlock was conducted in May 1994. The external airlock developed by Rockwell will provide the passage needed for the astronauts to enter the Mir; it also provides the attachment point for the docking mechanism. *Also* in preparation for docking with Mir. Rockwell took delivery of the Russian Flight Article Docking Mechanism in September 1994. The docking mechanism was integrated to the docking base and structure. tested, and accepted by NASA early in FY 1995. Other FY 1994

accomplishments included the first flight of a Russian cosmonaut on the Space Shuttle and the first delivery of American science payloads to Mir.

In February 1995, the crew of STS-63 will perform a rendezvous with and fly-around of the Mir. This flight will set the stage for STS-71 which will be the first of seven docking flights scheduled over the next three years. The STS-63 will also prepare for the flight of two cosmonauts on STS-71 by including one cosmonaut in its crew.

In March 1995. an American astronaut will be launched in a Russian Soyuz capsule to spend ninety days aboard the Mir. At the end of the ninety days, the STS-71 mission will dock to the Mir. deliver new crew members to the Mir. and bring back the American astronaut who was launched in the Russian Soyuz capsule. Docking with the Mir on STS-71 will require use of a special Orbiter Docking System which incorporates the docking mechanism which was developed by Russia for this flight. The design and fabrication of the docking mechanism has been thoroughly analyzed to ensure that its usage on a Space Shuttle mission will not endanger the crew or vehicle. During the docked phase of the flight, a number of joint scientific experiments will be performed using Mir and Space Shuttle-Spacelab equipment.

For STS-71, the primary objectives are to rendezvous and dock with the Mir, perform on-orbit. joint U.S./Russian life sciences and microgravity investigations, logistical re-supply of the Mir, return of the U.S. astronaut flying on the Mir, and the replacement of the Mir crew with two new cosmonauts. The life science and logistical resupply objectives will be met through the use of a Spacelab long module. Major experiments include the Baroreflex Experiment, the Lower Body Negative Pressure Experiment, the Graded Exercise Equipment, and the Protein Crystal Growth Experiment. Physiological, metabolic, and environmental data will also be collected. Transfer of Mir logistical hardware from the Spacelab to the Mir will also provide experience which will be very valuable in the transfer of U.S. experiment hardware to and from Mir on subsequent flights, and in using the international Space Station. Use of a Spacelab module on this important mission, and Spacelab pallets on subsequent missions to support the delivery of unpressurized cargo, provides a high probability of success since this hardware has been flight-proven many times over. Integration of the hardware required for this mission into the Spacelab. and then into the orbiter, is being accomplished according to well-proven procedures and equipment.

For the four missions which require pressurized habitable modules, NASA will be using modules provided by Spacehab, Inc. NASA is currently leasing two of Spacehab's pressurized modules under the Commercial Middeck Augmentation Module contract, which also provides integration and operation services. Spacehab, Inc. is the only commercial source with flight-certified modules capable of providing the required hardware and related services within the time required to support the NASA-Mir program. NASA intends to contract with Spacehab, Inc. for lease. integration and operations of modules for delivery of logistics and other equipment to Mir. To meet the STS-76 launch date which is a single module mission, payload integration activities began in November 1994. Design modifications to develop a double module capability to support STS-79 also began in November 1994. On November 17. 1994. a letter contract was signed with Spacehab, Inc. to initiate these activities. NASA anticipates receiving a proposal from Spacehab. Inc. in January 1995 with a formal contract being awarded by mid-March 1995.

In October 1995. the STS-74 mission will deliver a new docking module to Mir to allow Space Shuttles to dock in a more favorable position on the Mir. Two Space Shuttle missions will be flown to Mir in FY 1996. On the last FY 1996 Space Shuttle-Mir mission.

U.S. astronauts and Russian cosmonauts will perform a joint spacewalk to validate and demonstrate assembly techniques for the international Space Station.

FY 1996 funding for Spacehab will provide for initiation of integration support for the manifested logistics and equipment for delivery to Mir. Three more Space Shuttle-Mir missions will be performed in FY 1997. An option is being maintained to fly up to three additional Space Shuttle-Mir missions should they become necessary.

Space Shuttle

HUMAN SPACE FLIGHT

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE SHUTTLE**

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	page Number
Shuttle operations	2,549,000	2,415,297	2,394,800	HSF 3-3
Safety and performance upgrades	1.009.700	739.800	837.000	HSF 3-11
Total	3.558.700	3.155.097	3,231,800	
Distribution of Program Amount bv Installation				
Johnson Space Center	1,033,900	869,500	959,700	
Kennedy Space Center	929,400	835,000	808,800	
Marshall Space Flight Center	1,520,000	1.351,597	1,378,100	
Stennis Space Center	37.100	49,400	44,000	
Dryden Flight Research Center	5.700	6,100	5,600	
Goddard Space Flight Center	300	0	0	
Jet Propulsion Laboratory	100	0	0	
Headquarters..	32.200	43,500	35.600	
Total	3.558.700	3,155.097	3.231.800	

PROGRAM GOALS

The primary objective of the Space Shuttle program is to support NASA launch requirements while maintaining the essential program focus on safety and mission success, demonstrated since the Space Shuttle's return to flight. and expanding existing safety margins. Because of its unique capabilities, the Space Shuttle remains a key element of America's space program. The Space Shuttle is the first reusable space vehicle and can be configured to carry many different types of space apparatus, spacecraft, and scientific experiments. The Space Shuttle will serve as the primary transportation vehicle for assembling and operating with the international Space Station. In addition to transporting material, equipment, and spacecraft to orbit, the Space Shuttle offers unique capabilities such as retrieving payloads from orbit for re-use, servicing and repairing satellites and

observatories in space, as was demonstrated with the successful repair of the Hubble Space Telescope, safely transporting humans to and from space and operating and returning space laboratories.

STRATEGY FOR ACHIEVING GOALS

The FY 1996 budget for the Space Shuttle program provides for a program which will continue to improve safety margins, fly the established manifest, launch seven flights every year, provide a vehicle that must undergo significant modifications to operate with the international Space Station, and continue to reduce costs.

The budget structure of the Space Shuttle program consists of two major components: Space Shuttle Operations. and Safety and Performance Upgrades. Shuttle Operations supports the launch of NASA missions and is the primary program in which efficiencies have been implemented thereby significantly reducing the operational cost of flying the Space Shuttle. When measured from the program's FY 1992 actual budget, a 23% reduction will be realized with the FY 1996 budget. The Space Shuttle launch schedule plans for an annual flight rate of seven from FY 1995 through FY 2000. Safety and Performance Upgrades provides for modifications and improvements to the flight elements and ground facilities. including expansion of safety and operating margins and enhancement of Space Shuttle capabilities as well as the replacement of obsolete systems. In addition, this budget includes funding for facilities related to the Space Shuttle. In FY 1995 and FY 1996, selected facilities at the Johnson Space Center, the Kennedy Space Center, and the Stennis Space Center will be modified, refurbished and restored to acceptable conditions to improve their performance.

Safety modifications. such as upgrades to the main engine that significantly improve the Space Shuttle vehicle's overall safety, will achieve significant milestones in FY 1995 with first flight of the High Pressure Oxidizer Turbopump and Single Coil Heat Exchanger. Development of performance enhancements will provide increased payload lift capability for operating with the higher inclination required by the Space Station; and, obsolescence and environmental considerations must be dealt with as operations continue. However, the program is acutely aware that providing reliable access to space must be more cost-effective. Major cost reduction measures which have been underway since FY 1992 must continue as the program concentrates on becoming more efficient and effective. New approaches in procurement, organizational changes, and investments in new hardware efficiencies are being examined and implemented where contributions are evident. Space Shuttle functional workforce reviews initiated in early FY 1995 are specifically examining the Space Shuttle's total workforce, in detail, to identify areas where changes to Space Shuttle program requirements, plans or operations approach can lead to cost savings while safely supporting seven flights per year. NASA has also reviewed and updated the Space Shuttle pricing policy using data from the current budget submission. NASA and the Office of Management and Budget (OMB) have agreed that the Space Shuttle flight price would be based on recovery of average Space Shuttle operating costs, which includes a portion of recurring safety and performance upgrades. NASA is currently coordinating this flight price update with its international Space Station partners.

BASIS OF FY 1996 FUNDING REQUIREMENT

SHUTTLE OPERATIONS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Orbiter and integration	586.900	528,200	504,900
(Orbiter)	(387.900)	(359,800)	(352.700)
(System integration)	(199,000)	(168,400)	(152.200)
Propulsion	996.000	1,006,997	993.200
(External tank)	(252.200)	(329,600)	(328.000)
(Space shuttle main engine)	(189.2001	(149,200)	(145.600)
(Redesigned solid rocket motor)	(396.4001	(365.997)	(355.400)
(Solid rocket booster)	(158.200)	(162.200)	(164.200)
Mission and launch operations	966.100	880.100	896.700
(Launch and landing operations)	(650,100)	(626.400)	(612.100)
(Mission and crew operations)	(316.0001	(253.7001	(284.6001
Tot	2.589.000	2.415.297	2.394.800

PROGRAM GOALS

The goal of Shuttle Operations is to provide safe, reliable. and cost-effective access to space. Space Shuttle operations are manifested at a planned rate of seven flights per year from FY 1995 through FY 2000.

The Space Shuttle program is aggressively continuing to significantly reduce the cost of operations. Since FY 1992. cost reduction efforts have been successful in identifying and implementing program efficiencies and specific content reductions. Space Shuttle project offices and contractors have been challenged to meet reduced budget targets.

STRA FOR ACHIEVING GOALS

The Space Shuttle program provides launch services to a diversity of customers, supporting payloads that range from small hand-held experiments to large laboratories. While many missions are devoted to NASA-sponsored payloads, wide participation is exercised by industry, partnerships and corporations, academia and other national and international agencies. Both NASA and the U.S. scientific community are beneficiaries of this approach. The Space Shuttle is a domestically and internationally desired research facility because of its unique ability to provide on-orbit crew operations. rendezvous/retrieval, and payload provisions. such as power, telemetry, pointing and active cooling to payloads.

The Space Shuttle has numerous cooperative and reimbursable payloads involving many countries and international agencies. Examples of international participation which the Space Shuttle is uniquely suited to support include:

- the November 1994 launch of the German-built cooperative, Crista-SPAS
- the retrieval of the Japanese space flyer unit in late 1995
- the reflight of the Italian tethered satellite system in early 1996
- the flight of the CRISTA-SPAS free-flying payload, equipped with an international cargo of science instruments in mid-1997.

The Space Shuttle program is also integral to the domestic commercial development of space, providing flight opportunities to NASA's Centers for Commercial Development of Space. These non-profit consortia of industry, academia, and government were created to conduct commercially applied research activities by encouraging industry involvement leading to new products and services through the access to the space environment. Over 50 payloads with numerous experiments have been developed through these consortia and are scheduled for flight in FY 1995.

Cooperative activities with the National Institute of Health (NIH), the National Science Foundation (NSF). the Department of Defense and other U.S. agencies are advancing knowledge on human health. medicine, science. and technology. Space Shuttle support for the flight of Neurolab in 1998, a major cooperative NASA-NIH program, is a prime example.

Orbiter and Integration

The Orbiter program element consists of the following items and activities:

(1) Orbiter spares for the replenishment of line replacement units (LRUs) and shop replacement units (SRUs) along with the workforce required to support the orbiter logistics program:

(2) Production of external tank (ET) disconnect hardware:

(3) Flight crew equipment processing as well as flight crew equipment spares and maintenance, including hardware to support Space Shuttle Extra Vehicular Activity (EVA):

(4) Various orbiter support hardware items such as pyrotechnic-initiated controllers (PICS), NASA standard initiators (NSIs), and overhauls and repairs associated with the Remote Manipulator System (RMS):and

(5) The sustaining engineering associated with the orbiter vehicles is now included in this budget element.

The major contractors in this activity are Rockwell International. for logistics, external tank disconnects and sustaining engineering: and Hamilton-Standard, for flight crew equipment processing.

System Integration includes those elements managed by the Space Shuttle Program Office, including payload integration into the Space Shuttle and systems integration of the flight hardware elements through all phases of flight. Payload integration provides for the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable and safe cargo for each Space Shuttle mission. Systems integration includes the necessary mechanical, aerodynamic, and avionics engineering tasks to ensure that the entire launch vehicle can be safely launched, fly a safe ascent trajectory, achieve planned performance, and descend to a safe landing. In addition, funds are provided for multi-program support at the Johnson Space Center (JSC). Rockwell International. Space Division, is the major contractor for this function.

Propulsion

External tanks are produced by Martin-Marietta Corporation in the Government-Owned/Contractor-Operated (GOCO) facility near New Orleans, LA. This activity involves the following:

(1) Procurement of materials and components from vendors:

(2) Engineering and manufacturing personnel:

(3) Support personnel and other costs to operate the GOCO facility: and

(4) Sustaining engineering for flight support and anomaly resolution.

The program will begin delivering super lightweight tanks in support of the performance enhancement goal required by the Space Station in FY 1997. Only recurring costs associated with the Super Lightweight Tank are included in this account. Non-recurring costs are accounted for in the Safety and Performance Upgrades budget.

The Space Shuttle Main Engine (SSME) operations budget provides for overhaul and repair of main engine components, procurement of main engine spare parts, and main engine flight support and anomaly resolution. In addition. this budget includes funding to the Department of Defense for Defense Contract Auditing Service (DCAS) support in the quality assurance and inspection of Space Shuttle hardware. This also provides funds for transportation and logistics costs in support of SSME flight operations. Rocketdyne. a division of Rockwell International Corporation. provides the engines for flight and, Pratt-Whitney will begin providing an upgraded Alternate Turbopump (ATP) for flight in FY 1995.

The first milestone for implementing the ATP is the flight of the High Pressure Oxidizer Turbopump (HPOTP) with the single coil heat exchanger and phase 2+ powerhead as a "Block I" configuration in FY 1995. The Block II configuration will combine the High Pressure Fuel Turbopump (HPFTP) with the Large Throat Main Combustion Chamber (LTMCC) in FY 1997. Completion of this block change will significantly increase the main engine's operating safety margins, and as a result improve the overall Space Shuttle vehicle safety.

The Solid Rocket Booster (SRB) program supports:

(1) Procurement of hardware and materials needed to support the flight schedule:

(2) Work at various locations throughout the country for the repair of flown components:

(3) Workforce at the prime contractor facility for integration of both used and new components into a forward and an aft assembly: and

(4) Sustaining engineering for flight support.

The USBI. Inc. of Huntsville, AL, is the prime contractor on the SRB and conducts SRB retrieval. refurbishment and processing at the KSC.

The Redesigned Solid Rocket Motor (RSRM) budget includes:

(1) Purchase of solid rocket propellant and other materials to manufacture motors:

(2) Workforce to repair and refurbish flown rocket case segments. assemble individual case segments into casting segments and other production operations including shipment to the launch site:

(3) Engineering personnel required for flight support and anomaly resolution: and

(4) New hardware to support the flight schedule required as a result of attrition.

Thiokol of Brigham City, Utah is the prime contractor for this effort.

Mission and Launch Operations

Launch and Landing Operations provides the workforce and materials to process and prepare the Space Shuttle flight hardware elements for launch as they flow through the processing facilities at the Kennedy Space Center (KSC). This category also funds standard processing and preparation of payloads as they are integrated into the Orbiter, as well as procurement of liquid propellants and gases for launch and base support. It also provides for support to landing operations at KSC, Edwards Air Force Base and contingency sites, as required.

Operation of the launch and landing facilities and equipment at KSC involves refurbishing the Orbiter, stacking and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration, and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation. inventory management, and other launch support services. This element also provide funds for:

(1) Maintaining and repairing the central data subsystem, which supports Space Shuttle processing as an on-line element of the launch processing system:

(2) Space Shuttle-related data management functions such as work control and test procedures:

(3) Purchase of equipment, supplies and services: and

(4) Operations support functions including propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification. Space Shuttle landing facility upkeep, range support, and equipment modifications.

Mission and Crew Operations includes a wide variety of pre-flight planning, crew training. operations control activities, flight crew operations support, aircraft maintenance and operations. and life sciences operations support. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include:

(1) Flight planning:

(2) Preparing systems and software handbooks:

(3) Defining flight rules:

(4) Creating detailed crew activity plans and procedures:

(5) Updating network system requirements for each flight: and

(6) Contributing to planning for the selection and operation of Space Shuttle payloads.

Also included are developing, upgrading and establishing the Mission Control Center (MCC), Integrated Training Facility (ITF), Integrated Planning System (IPS), and the Software Production Facility (SPF). These four facilities integrate the mission operations requirements for both the Space Shuttle and Space Station. Flight planning encompasses flight design, flight analysis, and software activities. Both conceptual and operational flight profiles are designed for each flight, and the designers also help to develop crew training simulations and flight techniques. In addition. the flight designers must develop unique, flight-dependent data for each mission. The data is stored in erasable memories located in the orbiter, ITF Space Shuttle mission simulators, and MCC computer systems. Mission operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, ITF, IPS and SPF. Finally, Mission and Crew Operations includes maintenance and operations of aircraft needed for flight training and crew proficiency requirements. Other support requirements are also provided for in this budget, including engineering tasks at JSC which support flight software development and verification. The software activities include development, formulation, and verification of the guidance, targeting, and navigation systems software in the orbiter. Shuttle Operations requirements are met through a combination of funds received from Congressional appropriations and

reimbursements received from customers whose payloads are manifested on the Space Shuttle. The reimbursements are applied consistent with the receipt of funds and mission lead times, and are subject to revision as changes to the manifest occur. The FY 1995 planned reimbursements total $30.5 million.

MEASURES OF PERFORMANCE

Space Shuttle Missions and Primary Payloads

FY 1994		
STS-58/Columbia	Space Life Sciences Laboratory-2 (SLS-2)	October 1993
STS-61/Endeavour	Hubble Space Telescope Servicing Mission (HSTSM-01)	December 1993
STS-60/Discovery	Spacehab-2/Wake Shield Facility-1 (WSF-1)	February 1994
STS-62/Columbia	United States Microgravity Payload (USMP-2)	March 1994
STS-59/Endeavour	Space Radar Laboratory (SRL1)	April 1994
STS-65/Columbia	International Microgravity Laboratory (IML-2)	July 1994
STS-64/Discovery	Lidar In-Space Technology Experiment (LITE-1)	September 1994
STS-68/Endeavour	Space Radar Laboratory (SRL-2)	September 1994
FY 1995		
STS-66/Atlantis	Atmospheric Laboratory for Applications and Science (ATLAS-3)	October 1994
STS-63/Discovery	Spacehab-3	February 1995
STS-67/Endeavour	Astronomy (ASTRO-2)	March 1995
STS-71/Atlantis	Russian Space Station Mir (Mir-1)	May 1995
STS-70/Discovery	TDRS-G Satellite Deployment	June 1995
STS-69/Endeavour	Wake Shield Facility-2 (WSF-2)	July 1995
STS-73/Columbia	United States Microgravity Laboratory (USML-2)	September 1995
FY 1996		
STS-74/Atlantis	Russian Space Station Mir (Mir-2)	October 1995
STS-72/Endeavour	SFU Retrieval/OAST-Flyer Deployment	November 1995
STS-75/Columbia	Tether Satellite System Reflight (TSS-1R)/USMP-3	February 1996
STS-76/Atlantis	Russian Space Station Mir (Mir-3)	March 1996
STS-77/Endeavour	Spacehab-4	April 1996
STS-78/Columbia	Life/Microgravity Sciences (LMS-1)	June 1996
STS-79/Atlantis	Russian Space Station Mir (Mir-4)	August 1996

	FY 1994	FY 1995	FY 1996
Number of Space Shuttle Flights	8	7	7
Shuttle Operations Workforce (Prime Contractors)	17,996	16.594	15,701
Space Shuttle Processing Overtime	3%	3%	3%
Number of Days On-orbit	85	74	83
Number of Primary Payloads Flown	11	9	11

ACCOMPLISHMENTS AND PLANS

The requirements for Shuttle Operations are based on supporting the launch of seven Space Shuttle flights and their associated payloads. Each Space Shuttle project has been working to a very aggressive cost reduction program resulting from cost targets established by NASA management. These projects will continue to implement cost reductions in FY 1995 and in FY 1996 as well as the outyears by critically reviewing their current requirements and exploring new ways of doing business in order to determine the minimum resource level needed to support the manifest without compromising flight safety. The cost of Space Shuttle operations in FY 1996 is almost 6% less than FY 1994 and represents a significant challenge to the program. Both prime contractor and supporting personnel are being reduced across the program by contract restructuring. contract consolidation. utilization of civil service wherever possible. reevaluating processes, consolidating skills and reevaluating training requirements. In order to continue accommodating reductions of this magnitude, the program is currently examining major structural changes as well as changes to roles and missions.

In FY 1994, the Space Shuttle launched eight flights successfully including the Hubble Space Telescope (HST) repair mission and the second Spacelab mission dedicated to the life sciences. Other major payloads flown in FY 1994 include:

- materials processing in a microgravity environment for both U.S. and international customers:
- experiments involving molecular and chemical growth of compound semi-conductors in the Wake Shield Facility:
- Spacehab payloads for NASA-sponsored commercial customers:
- two separate missions with the Space Radar Laboratory: and
- over 45 middeck payloads.

Also. the first of the cooperative missions with Russia was initiated when a Russian cosmonaut became a shuttle crew member of STS-60 in February.

The Orbiter requirements are based on flight rate, maintenance schedules, operational usage, repair times, and lead times to procure new hardware or repair flown hardware. The requirements for System Integration are based on the flight rate, specific payloads manifested, and unique launch requirements such as inclination or performance requirements. The first flight to dock with the Russian Mir will be flown in May 1995 at a high inclination orbit. In addition, the full capability of an extended duration flight will be demonstrated with a sixteen-day mission to be flown with a U.S. Microgravity Laboratory (USML-2) payload in September 1995.

In early FY 1995. the Space Shuttle successfully launched STS-66, the ATLAS/CRISTA-SPAS mission. This was the third flight of the Atmospheric Laboratory for Applications and Science mission, a coordinated research effort to comprehensively study the planet's environment. Complementing the ATLAS science mission, the German-built Shuttle Pallet Satellite (SPAS) carried two experiments: CRISTA (Cryogenic Infrared Spectrometer and Telescopes for the Atmosphere: and, MAHRSI (Middle Atmosphere High Resolution Spectrograph Investigation). Seven additional experiments were also carried on this missions' mid-deck payloads.

In FY 1995, the Space Shuttle will fly an additional six missions including a microgravity flight, a Space Radar Laboratory flight, and the third flight of the commercial Spacehab module. These flights will also carry a multitude of secondary payloads. There will also be two extended duration flights of thirteen to sixteen days on Columbia (OV-102). In addition. the first visit and docking of the Space Shuttle to the Russian Mir is scheduled for May 1995, on STS-71. During this mission, an astronaut and two cosmonauts, who will have been aboard the Mir for more than two months, will be returned to Earth. Two cosmonauts who will be aboard the Space Shuttle, when launched from KSC, will transfer to the Mir and replace the two returning to the KSC.

The seven-flight manifest for FY 1996 includes three flights to Mir, a combined reflight of the Tethered Satellite and microgravity mission, the fourth flight of the commercial Spacehab Module. retrieval of two free-flyer satellites, one launched by the Japanese (SFU) and one launched by NASA, and one Spacehab mission.

The requirements for the External Tank, Solid Rocket Booster, and Redesigned Solid Rocket Motor are based on the flight schedule planned for FY 1995, FY 1996 and the outyears. The budget provides for production of hardware as well as purchase of long-lead hardware based on each project's unique manufacturing lead-time requirements. The External Tank production rate is increasing from four to five in FY 1995. as we continue to draw down the current inventory of tanks at KSC, to support the flight rate of seven missions. In addition, funds are provided to purchase materials to produce the super lightweight tank based on utilization of aluminum lithium. The requirements for the main engine are based on operational usage of flight hardware, repair times, and lead times to refurbish flown hardware. Safety modification in the form of "block" changes will be incorporated over the next several years to significantly improve safety of the engine and the vehicle overall. When all engines are modified, the shuttle vehicle's safety index will be improved by a factor of two.

Launch and Landing Operations funding in FY 1996 provides the workforce and support services necessary for processing the hardware and launch from the KSC, as well as to support landing operations at the KSC and Dryden Flight Research Facility and contingency sites. This includes the workforce to assemble the Solid Rocket Boosters (SRBs), mate the boosters and tanks, process the orbiter, mate the orbiter to the integrated SRBs and external tank, process and checkout integrated flight elements through launch, retrieve and disassemble the SRBs for refurbishment, and support landing of the orbiter. Funding also supports the KSC sustaining engineering, provisioning, logistics. launch processing system operation and maintenance, and maintenance/modification of all other Space Shuttle-related ground support equipment and facilities including Launch Complex 39. Mission operations primarily supports functions at the JSC to plan for and conduct Space Shuttle missions from launch to landing. The functions are to maintain and operate all the ground facilities necessary for flight preparation and execution: to train the flight and ground controller crews in all aspects of flight including EVA training: to maintain the proficiency of operational aircraft for training and orbiter ferry requirements: and to provide real-time support to each Space Shuttle mission.

BASIS OF FY 1996 FUNDING REQUIREMENT

SAFETY AND PERFORMANCE UPGRADES

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Orbiter improvements	204.300	194.800	227.900
Orbiter improvements	204.300	194.800	227.900
(Multifunction electronic display system)	(36500)	(37.900)	(40.600)
(Simplified aid for EVA rescue)	(0)	(8,300)	(9,900)
(Global positioning system)	(0)	(2,000)	(9,000)
(Other orbiter improvements)	(167800)	(146600)	(168400)
Propulsion upgrades	429.800	428.200	458.900
Space shuttle main engine upgrades	355.500	354.200	357.200
(Alternate turbopump program)	(66.0001	(98,200)	(124700)
(Other main engine upgrades)	(289.500)	(256,000)	(232500)
Solid rocket booster improvements	23.500	34.400	69.000
Super lightweight tank	50.800	39.600	32.700
Flight operations & launch site equipment upgrades	191.600	104.500	132.800
Flight operations upgrades	109.900	63.900	89.000
Launch site equipment upgrades	81,700	40.600	43.800
Advanced solid rocket motor (termination funding)	149,700		
Construction of facilities	34.300	12,300	17,400
Replace component refurbishment facility		(7,500)	
Modernize firex system. pads A and B		(4,800)	(5,000)
Replace space shuttle main engine processing facility			(4,900)
Replace chemical analysis facility			(7,500)
Total	1,009,700	739.800	837.000

NASA planning assumes continued utilization of the Space Shuttle through at least the year 2012, which is the planned life span of the international Space Station. In order to maintain a viable, manned transportation capability that will operate into the next century and support NASA's launch requirements, specific program investments are required.

The Safety and Performance Upgrades budget provides for these investments which include necessary improvements to expand existing safety margins and ensure continued safe and reliable Space Shuttle operations. In addition, the Space Shuttle's performance requirements have increased significantly with the change of the Space Station's orbital inclination from 28.5 to 51.6 degrees. In order for the Space Shuttle to achieve these higher inclination orbits, demand has been placed on the Space Shuttle system to increase its lifting capability by 13,000 pounds. This higher performance must be achieved by improving the propulsion system and reducing the overall weight of the shuttle system. In addition, this budget provides for modifying and improving the capability of the Space Shuttle to insure its viability as a safe space transportation system, reducing operational costs. meeting increasingly stringent environmental requirements, replacing obsolete systems and upgrading the ground systems for launch processing and mission operations.

STRATEGY FOR ING GOALS

The FY 1996 Safety and Performance Upgrades budget includes all development and investment activities necessary to expand safety margins, to continue to operate the Space Shuttle through the year 2012 and to improve the performance capability for operating with the Space Station. Activities funded by this budget include Orbiter Improvements, Space Shuttle Main Engine Upgrades, Solid Rocket Booster Improvements, Super Lightweight Tank, Launch Site Equipment Upgrades and Flight Operations Upgrades, as well as specific, Space Shuttle-related Construction of Facilities. Requirements to improve the Space Shuttle's performance affect all elements of the Space Shuttle system as well as continued development of the super lightweight external tank.

Orbiter Improvements

The Orbiter improvements program provides for enhancements of the Space Shuttle systems, produces space components that are susceptible to damage, and maintains core skills and capabilities required to modify and maintain the orbiter as a safe and effective transportation system. These activities are provided by contract arrangements with the Rockwell International Space Division in three major locations:

- the Downey, California facility provides engineering, manufacturing and testing;
- the Palmdale, California facility provides vehicle assembly, modification and testing; and,
- the Houston, Texas contingent provides engineering and problem resolution.

Other activities that support this effort are subsystem management engineering and analysis conducted by Lockheed, and development and modifications required for support to the extra-vehicular capability conducted by the Boeing Corporation and Hamilton-Standard.

Orbiter Maintenance Down Periods (OMDPs) are planned such that each orbiter is taken out of service periodically for detailed structural inspections and thorough testing of its systems before returning to operational status. These periods also provide opportunities for major modifications and upgrades, especially those upgrades that are necessary for improving performance to meet the Space Station operational profile. Since the orbiter is planned to operate into the next century. obsolescence as it affects safety and availability of materials and components is a continuing concern. In order to avoid the problems of obsolescence, this budget includes upgrading the orbiter's displays and controls to current aircraft standards. and upgrading the orbiter's navigation system used in the landing maneuver due to the planned phase out of the military's Tactical Air Navigation (TACAN) system.

Propulsion Upgrades

The Space Shuttle Main Engine upgrade program strives to improve operating margins by introducing safety, life extension, and producibility enhancements. Program funds include procurement of spare hardware, personnel. and other support needed to develop and test these enhancements. Introduction of the Alternate Liquid Oxygen and Fuel Turbopumps into the inventory of main engines in FY 1995 and FY 1997. respectfully, along with other improved components, will improve the shuttle vehicle's margin of safety by a factor of two.

The main engine safety and performance upgrade program is managed by the Marshall Space Flight Center (MSFC) and supports the orbiter fleet with flight-qualified engines and the necessary engineering and manufacturing capability to address any failure or anomaly quickly. The Rocketdyne Division of Rockwell International Corporation is responsible for operating three locations which provide engine manufacturing, major overhaul, component recycle and test. They are:

(1) Canoga Park, California which manufactures and performs major overhaul to the main engines:
(2) Stennis Space Center. Mississippi for conducting engine development, acceptance and certification tests: and
(3) Kennedy Space Center (KSC), Florida where the engine inspection checkout and rebuild activities are accomplished at the KSC engine shop.

Engine ground tests and flight date evaluation. hardware anomaly reviews and anomaly resolution are provided by the Marshall Space Flight Center. The Alternate Turbopump project is also managed by the MSFC under contract with Pratt-Whitney of Ft. Lauderdale. FL.

The Solid Rocket Booster (SRB) and Redesigned Solid Rocket Motor (RSRM) Improvement budget provides for enhancing the design of the current booster system to reduce its weight by 6.000 pounds (12.000 pounds per flight set). This results in an additional shuttle payload capability of 1200 pounds. Weight reduction is achieved through decelerator (parachute) subsystem material substitution and redesign, as well as modifications to the aft skirt. The RSRM performance enhancement includes the development of an aft exit cone extension. The resulting increase in specific impulse will translate into approximately 500 pounds

of additional payload capability. In direct support of NASA's goal to meet all energy and environmental standards, the RSRM effort includes development of asbestos-free insulation which is planned for certification by 1997. In addition to providing performance enhancements and insuring environmental compliance, this budget also funds development of the RSRM's nozzle production and refurbishment capability at the former Advanced Solid Rocket Motor Facility at Iuka, Mississippi.
Solid Rocket Booster/Motor activities are managed by the MSFC. The booster modifications are contracted through USBI of Huntsville, AL. and for the Redesigned Solid Rocket Motors are contracted with Thiokol of Brigham City, UT.

The most significant performance enhancement for achieving the Space Station's higher inclination orbit is the introduction of the Super Lightweight External Tank (SLWT). An 8,000 pound weight reduction will be achieved by selective substitution of high strength, low-density. aluminum-lithium alloys for the current aluminum alloys: optimization of structural design weight (selected redesign of certain structural components): and other weight savings measures. The launch date of the first SLWT is scheduled for the first space station assembly flight in early FY 1998. The proposed schedule includes the time required for the remaining design and development effort, the test of a tank dedicated for structural verification, the build of the first SLWT. and all the component requalification necessary for assurance that the SLWT has all the integrity of its predecessor.

Development of the SLWT is managed by the MSFC and is being accomplished at the Martin-Marietta Corporation facility at the Michoud Assembly Facility (MAF) near New Orleans, LA. After the tanks are built, tested and certified for flight. they will be shipped on government-owned barges to KSC where they will be processed for flight.

Flight Operations and Launch Site Equipment Upgrades

The major facilities at JSC include the Mission Control Center (MCC).the flight and ground support training facilities. the flight design systems and the training aircraft fleet that includes the shuttle training aircraft, the T-38 aircraft and the Space Shuttle Carrier Aircraft (SCA). Necessary improvements are being made for simulation training in both the Integrated Training Facility (ITF) and the MCC. The ITF upgrades include new host computers, interface hardware and simulator subsystems. The MCC will have improved console operations and communication equipment as well as new data processing and distribution systems. Critical reliability required for the longer integrated simulations will be substantially improved with these replacements. Also, associated maintenance costs will be reduced due to fewer computer breakdowns.

All shuttle processing prior to launch is performed at KSC. The launch of the Space Shuttle occurs with the vehicle under control of the KSC ground operations team. After SRB ignition, control is switched to JSC for the duration of the mission. After landing, control transfers back to KSC. At KSC. the ground processing facilities and equipment are undergoing upgrading and modifications to prevent obsolescence and avoid increased costs due to high maintenance and failure rates.

The major operational Space Shuttle facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), and three Mobile Launcher Platforms (MLPs).

Construction of Facilities

Construction of Facilities (CofF) funding for Space Shuttle projects is provided in this budget to refurbish, modify, replace and restore facilities at Office of Space Flight centers to improve performance, address environmental concerns of the older facilities, and to insure their readiness to launch the Space Shuttle.

MEASI OF PERFORMANCE

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the projects listed above consistent with approved schedule and cost planning and also the effect these projects have had on the operation of the Space Shuttle. Success depends on developing these projects and getting them implemented to help insure the Space Shuttle's safe operation, improve the reliability of the supporting elements, and improving efficiencies to reduce operational costs. This budget addresses all elements of the Space Shuttle program and is managed through an approval process that insures that new projects are evaluated, approved and initiated on a priority basis, and that existing projects are meeting established cost and schedule goals. Significant milestones are listed below:

Orbiter Improvements

Simolified Aid for EVA Rescue (SAFER) - SAFER is a small self-contained. one person free-flyer unit which provides an EVA self-rescue capability for the astronauts should they become inadvertently untethered from the Space Shuttle or Space Station

Conduct Critical Design (CDR) for SAFER - 4th Qtr FY 1995	Completion of CDR will allow production to proceed so that SAFER will be available for Space Shuttle-Mir joint spacewalk in FY 1996.
Initial SAFER demonstration - 4th Qtr FY 1996	Demonstrated on STS/Mir-04 flight

Multifunctional Electronic-Display System (MEDS) - MEDS is a state-of-the-art integrated display system that will replace the current orbiter cockpit displays with an integrated liquid crystal display system.

Complete MEDS Qualification Testing - 1st Qtr FY 1996	Complete hardware qualification testing and start hardware integration and verification testing
MEDS Initial Operational Capability (IOC) - 4th Qtr FY 1998	First flight of MEDS equipped orbiter.

Global Positioning Svstem (GPS) - GPS will replace TACAN in the orbiter navigation system when the military TACAN ground stations will cease to become operational in the year 2000. The planned readiness date for the Space Shuttle's system is FY 1999

Complete GPS Preliminary Design Review (PDR) - FY 1996	Completion of PDR will allow design drawings to proceed toward CDR
Complete GPS Critical Design Review (CDR) - FY 1997	Completion of CDR will allow drawings to be released for production to proceed.
Complete GPS operational capability - FY 1999	Operation of GPS without TACAN system

Orbital Maintenance Down Periods

Complete Columbia (OV-102) OMDP - 4th Qtr FY 1995	Routine Maintenance period for Columbia.
Conduct Discovery (OV-103) OMDP - 1st Qtr FY 1997	Conduct routine maintenance: outfit Discovery with external airlock; preparations for shuttle rendezvous with Mir and Space Station.
Initiate Endeavour (OV-105) OMDP - 4th Qtr FY 1996	Conduct routine maintenance and prepare Endeavour for station operations.

Propulsion Upgrades

Performance Enhancement Program - The performance enhancement program affects all elements of the Space Shuttle and is designed to provide 13.000 pounds of additional performance to allow rendezvous and operations with the international Space Station.

Critical Design Review (CDR) of Super Lightweight Tank - 3rd Qtr FY 1995	The Super Lightweight Tank will provide 8,000 pounds of performance through incorporation of an aluminum-lithium alloy in the external tank structure.
Aluminum-Lithium Test Article (ALTA) testing complete - 4th Qtr FY 1996	Completion of testing will certify the structural integrity of the external tank design and fabrication process.

Deliver first SLWT to KSC for flight - 4th Qtr FY 1997	Final assembly and checkout will be conducted at the Michoud Assembly Facility (MAF) in New Orleans, Louisiana.
Initiate test of Lightweight Booster Decelerator System - 3rd Qtr FY 1996	The lightweight booster will provide 1,200 pounds of performance enhancements through redesign of the decelerator (parachute system).
Deliver first Lightweight Booster to KSC for flight - 1st Qtr FY 1997	Initial flight capability.
Conduct Qualification Tests on RSRM Nozzle Cone Extension 4th Qtr FY 1997	Extending the RSRM Nozzle cone combined with increasing the diameter will increase the specific impulse and provide a payload gain of 500 pounds.
Delivery of initial RSRM production nozzle - April 1998	Initial flight capability

Space Shuttle Main Engine Safety Improvements - Introducing Block I and Block II changes into the Space Shuttle's Main Engine program will improve the margin of safety by a factor of two (2).

First flight of the Block I engine - 3rd Qtr FY 1995	The High Pressure Oxidizer Turbopump will be combined with single-coil heat exchanger and the phase 11+ powerhead.
High Pressure Fuel Pump Critical Design Review (CDR) 3rd Qtr FY 1996	Completion of CDR will allow production to proceed for implementation of the ATP high pressure fuel pump into the Block II Engine upgrade.
First flight of the Block II engine 4th Qtr FY 1997	The high pressure fuel turbopump will be combined with the large throat main combustion chamber (LTMCC).

Flight Operations and Launch Site Equipment Upgrades

Flight Operations Upgrades - Upgrades to the Mission Control Center will occur during FY 1995 and FY 1996 improving operations reliability and maintainability and also taking advantage of the state-of-the-art technology in displays and controls.

Begin on-orbit simulations from new MCC - 2nd Qtr FY 1995	Conduct a series of simulations to test new hardware/software in the MCC.

Begin on-orbit mission operations from new MCC - 2nd Qtr FY 1995	Conduct on-orbit simulations before ascent/entry to ensure system reliability
Begin ascent/entry mission support from new MCC with STS-73 - 1st Qtr FY 1996	Complete entire mission profile with the new MCC.
Complete replacement of displays and controls - 3rd Qtr FY 1996	Installation of new state of the art system will allow more efficient operations
Launch Site Equipment Upgrades	
Complete validation of Hardware Interface Modules (HIM Cards) - 3rd Qtr FY 1995	First production unit delivered and tested by user.

Construction of Facilities

Restore Fire Extinguisher Pumps and Piping at LC-39 - FY 1995	Restoration is needed. Pumps are currently inadequate to provide spray coverage during an emergency.
Replace Component Refurbishment and Chemical Analysis Facility at KSC -	Facility is 25 years old, in non-compliance with OSHA standards, overcrowded and insulated with asbestos. Completing this effort in FY 1996 is earliest opportunity to comply with CFC requirements during cleaning and degreasing operations.
Phase I - 2nd Qtr FY 1995	Begin Construction of component refurbishment building.
Phase 11 - FY 1996	Begin Construction of chemical analysis facility.

ACCOMPLISHMENTS AND PLANS

Budgetary pressures demand that the proper investments are made to promote efficiency of operations while, at the same time, insuring that the critical element of safety is maintained as a primary goal. The FY 1996 budget request for Safety and Performance Upgrades is the result of a project prioritization process that addresses safety first, then provides for performance enhancements, upgrades to prevent obsolescence and promote efficiency, and maintenance and logistics enhancements to improve reliability and operating efficiency.

A significant portion of the Safety and Performance Upgrades budget is dedicated to avoiding and preventing deleterious and costly effects of obsolescence, especially at a time when the program is undertaking the challenge of reducing the costs of operations. This portion of the budget contains projects that impact every element of the Space Shuttle vehicle. During FY 1996, development will continue on replacing the Orbiters cockpit displays with MEDS, replacing TACAN with GPS. upgrading the T-38 aircraft with maintainable systems, replacing elements of the launch site complex such as the cable farm and HIM cards, upgrading major elements of the Mission Control Center and training facilities at JSC. testing of main engine components at Stennis Space Center, testing of orbiter on-orbit propulsion systems at the White Sands Test Facility, and replacing critical subsystems in the KSC facility complex. At the KSC, phase two of the fire extinguisher upgrade will be conducted as will replacement of the chemical analysis lab and improvement of the main engine processing facility in the vehicle assembly building (VAB).

Orbiter Improvements

Orbiter Improvements provides for modifications and improvements that will insure compatibility of the shuttle vehicles with the new station operational environment. Orbiter weight reductions have been identified where operating experience or updated requirements allow selected items to be changed without impact to crew safety or mission success. The Orbiter weight will be reduced by changing the exterior thermal protection materials on certain portions of the orbiter, deleting portions of the orbital maneuvering and reaction control systems (OMS/RCS) that are no longer required, changing the material on the "flipper doors" that provide a seal between the orbiter wing and its control surfaces, and development of lighter weight crew seats for the cockpit. Additionally, funding will be used to analyze and certify the orbiter to fly safely with the super lightweight external tank and to land with the increased Space Station payload weight in an emergency situation.

The Orbiter vehicle continues to undergo other improvements on its own internal systems. For example, the Auxiliary Power Unit gas generator valve module is undergoing redesign to improve its reliability, the rate gyro assemblies underwent upgrades to improve their operational life, the thermal protection system underwent certification to allow the leading edge of the wing to experience higher temperatures during reentry, a new vendor was qualified for providing remote power controllers, and enhancements for improving the shuttle performance were initiated. Also in FY 1994, the Orbiter's Extended Duration project was completed which extends the on-orbit stay time beyond 14 days, with the first flight planned to exceed 14 days being STS-73 in FY 1995. Other improvements include developing a system to better contain the debris that occurs during the lift-off phase and threatens to damage the Orbiter, redesign of the water spray boiler, and introducing a bellows-type accumulator for the orbiter's hydraulic system.

The Space Shuttle's on-orbit steering system, known as the Reaction Control System (RCS), is being modified in order to increase its reliability which will improve maintenance and reduce life cycle costs. Operating experience to date has shown that the current RCS thrusters are being replaced often due to leakage, contamination or failure to fire. A new directing-acting valve is being designed and developed to replace the existing ones that are experiencing the most damage and failure. In the upgrade of the Direct Acting Valve (DAV) for the RCS, proof-of-concept testing on four DAVs were completed in FY 1994. In FY 1996, four development direct acting valves will be produced and tested followed by a critical design (CDR) review. Upon successful completion of the CDR, certification and qualification of this critical component will commence.

During FY 1994, Atlantis (OV-104) completed its OMDP and reentered the fleet in time to fly STS-66 in October 1994. Columbia (OV-102) followed Atlantis and is currently undergoing maintenance and structural inspections at the Palmdale. California facility and is expected to be complete in April 1995. In FY 1996, Discovery (OV-103) will enter OMDP at Palmdale for normal maintenance and checkout and will also be modified for docking with the international Space Station.

The Multifunctional Electronic Display System (MEDS) upgrade will replace the current orbiter cockpit displays which are early 1970's technology. The current displays which provide command and control of the Space Shuttle are "single string" electro-mechanical devices that are experiencing life related failures and are maintenance intensive. Difficulty in obtaining parts, some of which are no longer manufactured, is becoming more prevalent. The MEDS upgrade is a state-of-the-art, multiple redundant liquid crystal display (LCD) system. MEDS will enhance the reliability of the cockpit display system, resolve the parts availability problem, and provide a much more flexible and capable display system for the crew. This upgrade will bring the orbiter up to current aircraft standards having a direct benefit on the training of new astronauts. The MEDS was instrumental in helping develop the nation's first U.S. vendor for LCD glass thereby reducing dependence on overseas sources. The first lot of liquid crystal displays were delivered to the prime contractor for assembly and testing in FY 1994. Secondary benefits of MEDS are reductions in the orbiter's weight and also power consumption. The MEDS upgrade includes the design effort and production of modification kits for the four orbiter vehicles. New ground support hardware is also being designed and will be procured and installed to upgrade the appropriate simulators, test equipment, and laboratories. MEDS will be installed in the orbiters and tested during the planned OMDPs. In FY 1994, MEDS completed its critical design review, a significant milestone that allowed the production contract to proceed. The first flight of a MEDS equipped orbiter is planned for FY 1998.

Expansion of the effort to replace the orbiter's TACAN landing navigation system with the Global Positioning System (GPS) will begin in FY 1995. This expansion will include an increased interaction of the GPS receiver with the Orbiter backup flight software, and outfitting two more orbiters with a GPS test receiver. A number of development flights will take place with increasing GPS capability while still utilizing TACAN navigation. The first flight of a complete GPS system is planned for 1999.

In addition to modifying the orbiter itself for Space Station operations, production of SAFER (Simplified Aid for Extravehicular Rescue) will begin in FY 1995. SAFER will consist of a small propulsive backpack to be worn by each EVA crew member during all periods when the orbiter is docked to structure (e.g. spacewalking from the space station or the Mir complex) when rescue of an inadvertently-detached EVA crew member cannot be guaranteed. Currently, during spacewalks from the shuttle, EVA crew members are always tethered to prevent them from becoming separated. If an EVA crew member becomes inadvertently untethered, the shuttle can easily fly to the rescue. However, the Mir and the Space Station will not be maneuverable enough to rescue an inadvertently detached crew member, therefore, an autonomous self-rescue device must be provided.

The SAFER unit provides the overall best self-rescue capability, which was verified when a prototype was test flown on the STS-64 shuttle mission in FY 1994. Five SAFER flight units will be produced and fabricated along with two ground test and training units. Fabrication of the SAFER units will be accomplished by personnel at the Johnson Space Center. The first operational use of SAFER is scheduled for the joint spacewalk to be performed on a Space Shuttle-Mir docking flight in FY 1996.

Other orbiter activities include modifications to the portable life support system, redesign of the operating mechanism for external tank disconnect door, and accumulators for the hydraulic system and the waste collection system. Also, system integration and engineering tasks continue to support orbiter upgrades as they affect the entire vehicle including support for the Program Compliance and Assurance Status System (PCASS), which is a comprehensive engineering data base that examines failure histories across all shuttle elements. Orbiter modifications on subsystems such as the water spray boiler, the hydraulic system accumulators, the drive system for the external tank door and sensors for measurement of gaseous flows will be conducted to insure safety and reliability are maintained.

Propulsion Upgrades

The most complex components of the SSME are the high pressure turbopumps. Engine system requirements result in pump discharge pressure levels from 6000 to 8000 psi and turbine inlet temperatures of 2000 Degrees F. In reviewing the most critical items on the SSME that could result in a catastrophic failure, 14 of the top 25 are associated with the turbopumps. The current pumps dependence on extensive inspection to assure safety of flight have made them difficult to produce and costly to maintain. The Alternate Turbopump development (ATD) contract with Pratt & Whitney was signed in December 1986 and called for parallel development of both the high pressure oxidizer turbopump (HPOTP) and the high pressure fuel turbopump (HPFTP) to correct the shortcomings of the existing high pressure turbopumps. This objective is achieved by: utilizing design, analytical. and manufacturing technology not available during development of the original components: application of lessons learned from the original SSME development program: elimination of failure modes from the design: implementation of a build-to-print fabrication and assembly process: and full inspection capability by design. The turbopumps utilize precision castings, reducing the total number of welds in the pumps from 769 to 7. Turbine blades, bearings, and rotor stiffness are all improved through the use of new materials and manufacturing techniques. The SSME upgrades are dedicated to continuing progress toward providing the necessary improvements to expand existing safety margins and reduce operational costs. Significant progress was made in the main engine project during FY 1994 as the critical design review (CDR) for the Alternate Turbopump was completed. A major breakthrough allowed this program to proceed with full mission duration testing when the silicon nitride bearings were accepted for use in the high pressure turbopumps. Prior to this important event, the high pressure turbopumps were experiencing unacceptable bearing wear and shortening test periods with unplanned cut-offs caused by unacceptable vibrations. Once these bearings were tested, accepted and introduced into the ATD. testing proceeded successfully. One-hundred and eight tests were conducted during FY 1994 at the Stennis Space Center where over 50.000 test seconds of test time were accumulated.

The SSME powerhead is the structural backbone of the engine. connecting the two pre-burners powering the high pressure turbopumps to the main propellant injector. The powerhead is the attach point for the high pressure turbopumps and the main combustion chamber (MCC) and is also the duct for routing turbine discharge gas back to the main injector. The new Phase 11+ Powerhead will result in improved hot gas flow path characteristics from the high pressure fuel turbine to the main injector lox posts. Static and dynamic flow characteristics are improved throughout the hot gas flow path. The Phase 11+ Powerhead also reduces the number of welds, improving productibility and reliability.

The heat exchanger, mounted in the oxidizer side of the powerhead. uses the hot (800 - 900 degrees F) hydrogen-rich turbine discharge gases to convert liquid oxygen in a thin walled coil to gaseous oxygen for pressurization of the external oxygen tank.

The current heat exchanger coil has seven welds exposed to the hot gas environment. A small leak in one of these welds would result in catastrophic failure. The new single coil heat exchanger eliminates all seven critical welds and triples the wall thickness of the tube.

The large throat main combustion chamber (LTMCC)trades the gains realized in the improved powerhead for lower chamber pressure, resulting in lower pressures and temperatures throughout the engine system. The wider throat also accommodates additional cooling channels and an accompanying reduction in hot gas wall thickness. Hot gas wall temperatures are significantly reduced, which increases chamber life. The LTMCC design also incorporates investment cast manifolds into the fabrication technique to reduce the number of critical welds and improve the productibility of the chamber.

The "block" change concept for incorporating changes into the main engine was introduced and baselined during FY 1994. The Phase 11+powerhead, the single coil heat exchanger and the new high pressure oxidizer turbopump comprise Block I. This change will be introduced and flown for the first time in FY 1995. The Block II is scheduled to be flown in FY 1997 and consists of the large throat heat exchanger and the high pressure fuel turbopump. The end result of these engine improvements is an increase in the overall engine durability, reliability and safety margin, and productibility. This is consistent with NASA's goals of decreasing failure probability and reducing Space Shuttle costs.

Further safety margins and launch reliability on the Space Shuttle will be realized through the implementation of engine health monitoring capability. SSME history has shown that the engine is more reliable than the instrumentation system, however, a transducer failure could result in a flight scrub or on-pad abort, failure to detect an engine fault, or in-flight abort. NASA's health monitoring strategy is to improve the reliability of sensors and then incorporate controller improvements such as expanded and radiation hardened (to prevent single event upsets) memory, flight acceleration safety cut-off system redlines, and transducer qualification algorithms. These sensor upgrades are essential to improving the reliability of the Space Shuttle's launch capability and are planned for incorporation into the fleet beginning in FY 1995.

During FY 1994, the solid rocket booster project initiated delivery of the enhanced multiplexer-demultiplexer device, an improved electrical distribution system that will better withstand pressures and the severe reentry and impact environment experienced by the boosters after launch. In addition, the effort was initiated to integrate the RSRM nozzle fabrication and refurbishment capability into the facilities previously planned for the canceled Advanced Solid Rocket Motor (ASRM) program at Iuka, Mississippi. During FY 1995, both projects will contribute to the performance enhancement initiative. The SRB has initiated development of the lighter weight booster and the RSRM is extending the exit nozzle in order to provide more specific impulse during launch.

The super lightweight external tank contract received authority to proceed in FY 1994 as progress in developing an acceptable welding process proved satisfactory. The project completed casting of the thin plate test article proving the concept of weldability of this material and also completed the design review for the aluminum-lithium test article (ALTA). During FY 1995, both a Preliminary Design Review (PDR) and a Critical Design Review (CDR) will be conducted leading to the release of drawings to the manufacturing process at the Michoud Assembly Facility.

Flight Operations and Launch Site Equipment Upgrades

These facilities support the pre-launch and post-landing processing of the four orbiter fleet. Key enhancements funded in launch site equipment include: implementation of a digital operational intercom system (OIS-D); replacement equipment for the Launch Control Center, replacement storage tanks and vessels for the propellants, pressurants. and gases: an improved hazardous gas detection system (HGDS II); fiber optic cabling: and installation of a new orbiter ground cooling system.

The Hardware Interface Module (HIM) cards, which are electrical command distribution systems, that support the launch processing system (LPS) at KSC are over 25 years old and have experienced an increased failure rate and higher cost of repair over the past several years. The HIM upgrade will replace all chassis and cards with state-of-the-art "off the shelf' hardware to improve system reliability and maintainability. Design reviews have been completed and procurement was initiated in FY 1993. Installation should be completed by FY 1998.

The cable plant upgrade at KSC has been initiated to replace the miles of cables which support a wide variety of Space Shuttle facilities. Many of these cables were installed in the 1960s and are suffering from corrosion and increasing failure rates. Replacement will reduce the potential for disruption to critical Space Shuttle operations as well as have a direct maintenance benefit. This activity will reduce the possibility of launch delays, increase communication system spares availability, and enhance the reliability of data, instrumentation, voice, and video communications. This upgrade will replace the wide-band distribution system and the lead/antimony sheath cables with fiber optics and plastic sheath, gel-filled cable. In addition, many field terminals will be replaced or upgraded. Obsolete cable systems will also be replaced with current technology.

With the termination in 1994 of the Control, Checkout and Monitoring System Upgrade (CCMS-II), the current CCMS system will be modernized to meet concerns of obsolescence. This is a much more cost-effective approach than developing a new system, due in part, to prioritization of projects within the available budget.

Equipment obsolescence items at KSC include replacement of the portable purge units (PPU) and launch pad chiller equipment. PPU's are required to purge and clean the air in the contained areas around the Space Shuttle engines to prevent accumulation of explosive and toxic gases and pad chillers are required to cool the computers during the launch sequence. Increasing maintenance cost, high failures that pose environmental hazards due to leaking of freon and increasing vendor costs are reflective of obsolescence and environmental concerns.

The Day-of-Launch-I-Load Update System, Version 2 (DOLILU-II) is designed to reduce flight and mission preparation costs while maintaining high launch probability for all mission profiles. Current first stage mission designs baselined months before the flight are replaced with a design built, assessed and uplinked to the vehicle on the day of launch. The system builds new first stage steering commands based on upper level winds measured four hours prior to launch time. Additional processors assess the new trajectory against system constraints to insure mission safety. The system replaces months of preflight development and assessment of first stage flight designs. The DOLILU-II will also contribute to the ability for the Space Shuttle to launch within the required five minute window required for operations with the Space Station. Initial design reviews for the DOLILU-II were completed in FY 1994 and the first flight using this system is scheduled for FY 1995.

Funds for other activities include implementing required modifications and upgrades on the T-38 aircraft used for space flight readiness training, capability improvements for weather prediction, and enhancements on information handling to improve system monitoring, notably for anomaly tracking.

Construction of Facilities

FY 1994 Construction of Facilities (CoF) funding concentrated on the facilities at KSC. JSC and SSC. At SSC. the main engine B-1 test complex was restored to insure continued reliable, single stand test operations beyond FY 1997. At JSC. the air handlers in the Mission Control Center were replaced. This replacement provided for the conversion of an energy saving variable air volume system by replacing six large built-up air handlers and also adding an extension on the north end of the building to house the new air handlers. The thermal vacuum helium refrigeration system was also replaced. This provides for replacing obsolete helium refrigerators with new larger helium refrigerators in the Space Shuttle Engineering Simulator (SES) laboratory. This system was also at the end of its design life and threatening possible impact on program schedules. At KSC, FY 1994 funding supported several facility improvements. At launch complex 39, the exterior utility piping was restored, the cooling system was refurbished, the secondary circuit breaker system was refurbished and the C-5 substation was restored.

FY 1995 CoF funding is concentrated on the KSC facilities. The fire extinguisher piping for launch pads A and B are in need of restoration as they are currently considered inadequate to provide spray coverage during an emergency water flow. In addition, the underground piping between pump stations and launch pads is 25 years old and will not support pressures of the higher flow rates. The 25 year old facility at KSC used for components refurbishment is in non-compliance with OSHA fires safety standards, is overcrowded and is to be replaced. This project replaces approximately 30.000 square feet for rough and pre-cleaning, precision cleaning clean rooms and test cells, hydraulics laboratories and other support space.

FY 1996 CoF funding is also concentrated on KSC facilities. The Chemical Analysis facility is overcrowded and is in non-compliance with OSHA fire safety standards. The project replaces chemical analysis laboratories and other support space, a hypergolic decontamination building, and a hazardous waste storage building. The existing Space Shuttle Main Engine Shop will be replaced by an addition to Orbiter Processing Building 3. Finally, there will be an upgrading of the fire extinguisher pumps, motors, and diesels serving Launch Pads A and B fire extinguisher system. For additional details on these projects, please refer to the Mission Support - Construction of Facilities budget.

Payload and
Utilization Operations

HUMAN SPACE FLIGHT

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **PAYLOAD AND UTILIZATION OPERATIONS**

SUMMARY OF ES REQUIREMENTS

	FY 1994	FY 1995	FY 1996	page Number
		(Thousands of Dollars)		
Spacelab	125.500	98.600	97.000	HSF 4-3
Tethered satellite system	7.400	7.400	3.800	HSF 4-7
Payload processing and support	85.100	36.300	30.300	HSF 4-9
Advanced projects	7.200	12.200	12.200	HSF 4-11
Engineering and technical base	180.400	165.600	171.700	HSF 4-16
Total	405.600	320.100	015.000	
Distribution of Program Amount bv Installation				
Johnson Space Center	116.400	75.200	78.400	
Kennedy Space Center	136.800	101.100	90.700	
Marshall Space Flight Center	139.000	128.100	121.600	
Stennis Space Center	2.400	1.800	1.700	
Langley Research Center	300	0	500	
Lewis Research Center	100	300	300	
Goddard Space Flight Center	8.900	9.200	9.900	
Jet Propulsion Laboratory	100	0	0	
Headquarters	1.600	4.400	11.900	
Total	405.600	320.100	315.000	

PROGRAM GOALS

The primary goal of the Payload and Utilization Operations is to support the processing and flight of shuttle payloads to ensure maximum return on the research investment, to reduce operations costs, and to continue to implement flight and ground systems improvements.

STRATEGY FOR ACHIEVING GOALS

The principal areas of activity in Payload and Utilization Operations include the operation of the Spacelab systems: cooperative reflight of the U.S./Italian Tethered Satellite System (TSS): Payload Operations for accommodating NASA payloads: Advanced Projects: and the preservation of an Engineering and Technical Base (ETB) capability at the human space flight centers. The activities of these programs are accomplished by civil service and contractor personnel. Over the past several years. NASA has been extremely successful in reducing processing time and error rates while increasing customer satisfaction and controlling cost. NASA will continue to implement operational efficiencies gained-to-date plus assumptions of additional efficiencies by eliminating duplicative activities, and by accepting minor risk increases by eliminating some testing and analysis during payload processing. Workforce reductions achieved to date have not impacted schedule time and the FY 1996 strategy includes plans to further reduce the workforce while maintaining or continuing to improve customer satisfaction.

BASIS OF FY 1996 FUNDING REQUIREMENT

SPACELAB

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Spacelab	125.500	98.600	97.000

PROGRAM GOALS

Spacelab is a versatile, reusable, cost-effective observatory and laboratory facility located in the Space Shuttle payload bay to support a wide variety of science and technology development experiments which are developed by the utilizing programs within NASA and other external organizations. Spacelab serves as both an observatory and a laboratory, giving scientists the opportunity to conduct a large variety of scientific experiments in the unique environment of space.

STRATEGY FOR ACHIEVING GOALS

Ten foreign nations, including nine members of the European Space Agency (ESA).participated in the joint Spacelab development program with NASA. The ESA designed, developed, manufactured and delivered the first set of Spacelab hardware which consisted of a pressurized module, five pallets, subsystem support hardware (e.g. igloo, Instrument Pointing Subsystem (IPS). racks. avionics, computers) and much of the ground support hardware and flight and ground software.

Spacelab is configured within the orbiter bay in numerous ways to accommodate scientific experiments in the unique environment of space. "Hands on" experiments requiring astronaut participation use the pressurized module configuration while experiments not requiring a pressurized environment or requiring experiment visual access to space use the unpressurized pallet configuration. The module is pressurized and thermally-controlled to enable astronauts to work in a "shirt sleeve" environment. Easy crew access from the orbiter middeck to the module is enabled by the Spacelab tunnel. Module missions largely consist of life and microgravity sciences experiments.

Spacelab pallet missions are designed to accommodate up to five pallets in the orbiter bay, depending on the experiment requirements. In the event the experiment requires the use of the Spacelab computers and other avionics hardware which must be protected from the space environment, then the igloo is used to house the hardware and is flown as an attachment to the pallet. Other pallet configurations include the Spacelab Pallet System (SPS). One configuration supports missions requiring the use of the Spacelab computer system and pallet in a mixed cargo configuration (i.e., more than one major payload flown in the orbiter bay rather than a single major payload flown using the igloo subsystem).

Support software and procedures development, testing, and training activities are also included in NASA's funding request. Additional Spacelab hardware, including spares, are being procured from European and U.S. sources as needed to support the flight manifest.

Spacelab operations support includes mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, systems operation support, payload operations control support, payload processing, logistical support and sustaining engineering. The Spacelab operations cycle is repeated with each Spacelab flight but with a different payload complement. This cycle consists of three processing integration steps. Spacelab Level IV processing performs the integration and checkout of the experiment equipment with individual experiment mounting elements like racks, rack sets, and pallet segments, and is funded by the payload sponsor. This activity is normally performed at the Kennedy Space Center (KSC) but is not part of the Spacelab Operations budget. Spacelab Level III/II processing then combines and integrates all experiment mounting elements like racks, rack sets and pallet segments, which have the experiment equipment already installed and ready for checkout with the Spacelab software. This processing activity is also done at KSC and is funded under the Spacelab budget.

Spacelab Operations also funds smaller secondary payloads like the Get-Away Specials (GAS) and Hitchhiker payloads. The GAS payloads are research experiments which are flown in standard canisters that can fit either on the sidewall of the cargo bay or across the bay on the GAS bridge. They are the simplest of the small payloads with limited electrical and mechanical interfaces. Approximately ninety seven GAS payloads have been flown. The Hitchhiker payloads are the more complex of the smaller payloads; they provide opportunities for larger, more sophisticated experiments. The Hitchhiker system employs two carrier configurations: (1) an orbiter payload bay sidewall configuration and (2) an across payload bay configuration that uses a Multi-Purpose Experiment Support Structure (MPESS). During the mission, the Hitchhiker payloads can be controlled using the aft flight deck computer/standard switch panels or from the ground through the Payload Operations Control Center.

Another item funded in Spacelab operations is the Flight Support System (FSS). The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair. and retrieval of spacecraft. The FSS was used on the Hubble Space Telescope (HST) repair/revisit mission.

A major operational cost reduction program has been underway over the past year, with a goal of reducing the Spacelab budget by 30 percent. That reduction has been achieved for FY 1995 and we are confident that additional savings will be found during FY 1995 to meet our goals for FY 1996 and FY 1997.

Payload analytical integration is the responsibility of the Payload Projects Office at the Marshall Space Flight Center (MSFC), and is supported by a contract with McDonnell-Douglas. Physical payload integration and processing is the responsibility of the Payload Management and Operations Office at the KSC, and is supported by a contract with McDonnell-Douglas.

MEASURES OF PERFORI

Spacelab Missions

Space Life Sciences Laboratory-2 (SLS-2)	October 1993
United States Microgravity Payload (USMP-2)	March 1994
Space Radar Laboratory (SRL-1)	April 1994
International Microgravity Laboratory (IML-2)	July 1994
Lidar In-Space Technology Experiment (LITE-1)	September 1994
Space Radar Laboratory (SRL-2)	September 1994
Atmospheric Laboratory for Application and Science (ATLAS-3)	October 1994
Astronomy (ASTRO-2)	March 1995
Russian Space Station Mir (Mir-1)	May 1995
United States Microgravity Laboratory (USML-2)	September 1995
Tether Satellite System Reflight (TSS-1R)	February 1996
United States Microgravity Payload (USMP-3)	February 1996
Life/Microgravity Sciences (LMS-1)	June 1996
Microgravity Science Laboratory (MSL-1)	April 1997
United States Microgravity Payload (USMP-4)	October 1997
Space Life Sciences Laboratory-4 (Neurolab)	February 1998

Flight Hardware Utilized	FY 1994	FY 1995	FY 1996
Long Module	2	2	1
Multi-Purpose Experiment Support Structures (MPESS)	1		1
Pallets	1	2	
Pallets Plus MPESS	2		2
Hitchhiker Experiments	7	10	TBD
Get Away Special Payloads	22	7	TBD

ACCOMPLISHMENTS AND PLANS

Two Spacelab module missions were flown in FY 1994. namely the Space Life Sciences-2 (SLS-2) and the International Microgravity Laboratory (IML-2) missions. In addition, three pallet missions, (Space Radar Lab 1 and 2 and the LITE) and the MPESS (USMP-2) were flown. In addition to the support of these missions, analytical integration, configuration management, and software development for future flights were conducted. The X-Band Synthetic Aperture Radar (X-SAR) antenna flown in conjunction with the SRL-1 mission was designed and developed by the German and the Italian aerospace communities. The

IML-2 mission flew numerous experiments which were developed by the ESA, National Space Development Agency of Japan (NASDA), the Canadian Space Agency, and the French Government. Numerous foreign governments participated in the LITE mission by acquiring aircraft laser data simultaneously during LITE fly overs. The National Institute of Health has participated in the middeck portion by flying approximately six middeck experiments in FY 1994 with more experiments scheduled to fly in the coming year.

The FY 1995 Spacelab program funding reflects the program requirements to conduct Spacelab missions consistent with the manifest. The Atlas-3 is the first mission flown in FY 1995. Other missions to be flown include the Astro-2 pallet mission, the Space Shuttle-Mir (S/MM-1) module flight to the Russian Mir space station, the USML-2 module mission, numerous GAS payloads and three Hitchhiker bridges with ten Hitchhiker experiments.

In FY 1996. Spacelab program will fly the following manifested missions: the Tether Satellite System Reflight. USMP-3. S/MM-2 pallet mission, the Life and Microgravity Sciences (LMS) module mission and several GAS and Hitchhiker payloads.

BASIS OF FY 1996 FUNDING REQUIREMENT

TETHERED SATELLITE SYSTEM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Tethered satellite system reflight.....	7,400	7,400	3.800

PROGRAM GOALS

To study the electrodynamic behavior of the satellite-tether-orbiter system as it interacts with the charged particles and electric and magnetic fields within the Ionosphere, and to complete verification of the capability and utility of a Space Shuttle-based tethered satellite system (TSS).

STRATEGY FOR ACHIEVING GOALS

The TSS is a cooperative program with Italy to provide a reusable space facility for conducting space experiments at distances up to 100 kilometers from the Space Shuttle Orbiter while being held in a fixed position relative to the Orbiter. During the demonstration mission flown in August 1992. the TSS verified its capability to provide a dynamically stable research facility, but a mechanical interference in the deployment system prevented full deployment of the tether and satellite and completion of the science mission. In response to an Italian Space Agency request to refly the mission, NASA conducted a reflight study, including an independent assessment of NASA's future use of tethered satellites. The study concluded that a reflight mission could be readily accomplished and recommended several improvements to enhance the probability of success. The independent assessment identified a number of significant and unique science and engineering objectives which can be accomplished using tethered satellites, and urged the continued development and utilization of the tethered technology. NASA agreed to refly the TSS-1 mission in February 1996.

NASA is responsible for overall program management, overall systems engineering and integration, orbiter integration, ground and flight operations, development of the deployment mechanism and provision of the non-European instruments (Office of Space Science funded). NASA made substantial cost reductions in FY 1995 and FY 1996 by using in-house Marhsall Space Flight Center personnel to perform the TSS-1R integration and operations. Italy is responsible for the design and development of the satellite and the European instruments being flown on the joint mission. The United States Air Force sponsors one of the TSS-1R investigations.

MEASURES OF PERFORMANCE

System functional test of deployer	September 1994 (completed as scheduled)
Deployer turnover from prime contractor to NASA	September 1994 (completed as scheduled)
Deliver science instruments to KSC	February 1995
Begin Level IV experiment integration	March 1995
Satellite turnover from ASI/ALENIA to NASA	April 1995
Begin simulation training	August 1995
Independent assessment of mission readiness	1st Qtr 1996
Launch TSS-1R	February 1996

ACCOMPLISHMENTS AND PLANS

In FY 1994. the TSS was modified to correct TSS-1 anomalies and to enhance the mission success of TSS-1R. In addition, the MSFC in-house personnel were trained to do TSS-1R integration and operations and this responsibility was transferred from the prime contractor. In FY 1995. NASA will complete payload operations control center mission peculiar modifications, conduct simulation training and begin Level IV experiment integration. After a final end-to-end communications test. the TSS-1R hardware will be installed in the Space Shuttle (STS-75) and launched in February 1996. Following the mission, the hardware will be de-integrated and either returned to Italy or stored for future NASA use.

SI OF FY 1996 FUNDING REQUIREMENT

PAYLOAD PROCESSING AND SUPPORT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Payload processing and support.....	85,100	36.300	30,300

PROGRAM GOALS

The primary goal for Payload Processing and Support is to provide the capability to safely and efficiently assemble, test, checkout, service, integrate and launch a wide variety of spacecraft and space experiments.

STRATEGY FOR ACHIEVING GOALS

The Payload Processing and Support program provides the technical expertise, facilities and capabilities necessary to perform payload buildup. test and checkout, integration of multiple payloads, servicing, transportation to the launch vehicle, integration and installation into the launch vehicle, and launch. Included in this program are operational efficiencies gained to date, as well as additional efficiencies to be gained to reduce cost and improve customer satisfaction. Efficiencies already in place have reduced processing time and error rate. Workforce reductions currently in place have not impacted schedule time, and the FY 1996 strategy includes plans to further reduce the workforce while maintaining or continuing to improve customer satisfaction trends.

MEASURES OF PERFORMANCE

Missions Supported	FY 1994	FY 1995	FY 1996
Space Shuttle Missions	8	7	7
Spacelab Missions	6	4	4
Hitchhiker Experiments	7	10	TBD
Get-Away Special Payloads	22	7	TBD
Spacehab	1	1	2
Other Major Payloads	4	5	3
Expendable Launch Vehicles	5	11	5
Number of Payload Facilities Operating at KSC	10	6	6

ACCOMPLISHMENTS AND PLANS

In FY 1994, eight Space Shuttle mission payloads were processed successfully and on-time. Payloads included Space Radar Lab (SRL-1.2). Lidar In-Space Technology Experiment (LITE), Spartan 201-02. United States Microgravity Payload (USMP-2). International Microgravity Laboratory (IML-2) and Hubble Space Telescope serving mission, Spacehab-2. and the Office of Aeronautics and Space Technology payload (OAST-2). Additionally, customer payload processing support and processing facilities were provided for 22 major and secondary payloads. Support to our International partners was provided on four of these missions. Equipment replacement included the complete replacement of the toxic fuel scrubber at the Vertical Processing and Payload Hazardous Servicing facilities. The Kennedy Space Center Network Fiber Distribution Data Interface and the Engineering Data File Management systems were developed.

In FY 1995. payload processing and support funding will provide launch and landing payload support activities for seven Space Shuttle missions and payload processing support and facilities for twenty-eight major and secondaq payloads. During FY 1995, payload processing and support will be provided to Atmospheric Laboratory for Application and Science (ATLAS-3). Tracking and Data Relay Satellite (TDRS-G), Spacehab-3. Astronomy (ASTRO-2), SPARTAN 201-3, United States Microgravity Laboratory (USML-2), and Space Shuttle-Mir (S/MM-1) payloads. Four of the ten payload processing facilities will be closed prior to the end of the year to achieve program savings.

The FY 1996 funding will provide payload processing and support for seven Space Shuttle missions and the necessary customer payload processing facilities and support for 18 major and secondary payloads. The payloads to be processed in FY 1996 include not only those provided by American industries and universities, but also those provided in cooperation with our international partners. The major payload that involves partner cooperation is the reflight of the Italian Tethered Space Satellite (TSS-1R). Work will continue on the refurbishment of the instrument and control system and the environmental control system of the payload canister and transporter with completion anticipated within the fiscal year.

BASIS OF FY 1996 FUNDING REQUIREMENT

ADVANCED PROJECTS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Advanced projects	7,200	12,200	12,200

PROGRAM GOALS

The primary goals of the program are to continue to enhance crew safety for both the Space Shuttle and the Space Station, to pursue technology developments contributing to a reduction of Space Shuttle program costs, and to continue to implement flight and ground systems improvements. Secondary goals of the program are to promote transfer of advanced technologies, significantly increase the number of cooperative agreements, promote environmental alternatives to incorporate compliance solutions and pollution prevention, support leading edge technology to enhance safety, operational capabilities and cost efficiencies, and to develop a fully capable, diverse and motivated workforce. The Advanced Projects activity includes two major program elements: the Advanced Operations program and the Advanced Space Systems program.

STRATEGY FOR ACHIEVING GOALS

The Advanced Operations program supports projects which improve ground and flight operations of current and future human spaceflight vehicles by identifying. advocating and demonstrating available technologies and processes which are more efficient. cost effective, reliable, have dual use potential. and meet safety and performance requirements. The projects supported by the program are selected from a prioritized pool of candidate projects proposed by the operations Centers. The selected projects will be developed to a prototype level and demonstrated to meet their objectives within three years. Successfully-demonstrated projects will be transitioned to an operational program for implementation and to a private enterprise for commercial development. Linkages to Historically Black Colleges and Universities (HBCU)and to Small or Minority-Owned Businesses are sought and encouraged.

Several Advanced Operations projects have been jointly funded, either in their development or their commercialization, by other government agencies such as the Department of Energy or the State of Florida, private industry in either cooperative agreements or Space Act Agreements, or other NASA offices such as the Office of Space Access and Technology. The Advanced Operations program places a high priority on leveraging its limited funds through partnerships with other fund sources, public and private, to enhance its ability to achieve its goals.

The Advanced Space Systems program conducts flight demonstration experiments to validate critical advanced technologies in a relevant environment. The program identifies and demonstrates available technologies and processes which are efficient, cost effective, reliable, and meet safety and performance requirements. Projects are matured to a protoflight level, utilizing existing

carriers as testbeds for developing space flight hardware and operational processes to ensure their readiness to meet operational requirements. Flight demonstrations also provide training for young NASA engineers and managers with early "hands-on" flight hardware experience.

The Orbital Debris program is an international cooperative program jointly funded with the space agencies of Russia, Japan. and the European Space Agency. NASA has a series of cooperative programs with other spacefaring nations to measure, model, and mitigate the orbital debris environment. Other U.S. government agencies including the Department of Defense, the Department of Commerce, Federal Communication Commission, Department of State, and the Office of Science and Technology Policy rely on the products of the NASA Orbital Debris program to develop national and international policy relative to the mitigation of orbital debris.

MEASURES OF PERFORMANCE

The success of the Advanced Projects activities has been, and will continue to be, measured by the success of its projects. Over 100 projects have been supported in the past six years, most of which have been successful in delivering products which enhance the efficiency and reduce the cost of ground and flight operations. The following events represent significant milestones in the successful completion of this program:

Advanced Operations

Deliver instrumentation component failure data sharing to the MCC - 2nd Qtr FY 1995	Enables electronic data sharing of instrumentation system component failure among all Mission Control Center (MCC)flight monitoring workstations.
Deliver rendezvous operations data sharing to the MCC - 3rd Qtr FY 1995	Provide computer-derived trajectory data related to rendezvous operations to all MCC flight monitoring workstations.
Deliver final version of Visual Prox Operations System Software to the MCC - 4th Qtr FY 1995	Enables flight controllers in the MCC to visualize final phase of Space Shuttle/Mir docking utilizing tracking and trajectory data only.
Migrate Mission Information System and Electronic Documentation System to the MCC - 1st Qtr FY 1996	Provides paperless documentation capability to the MCC and flight support offices at the Johnson Space Center, to remote payload support offices, and to the flight vehicle.

Advanced Space Systems

Static Feed Electrolyzer (SFE) Flight Demonstration Critical Design Review - 1st Qtr FY 1996	This flight demonstration will validate the microgravity sensitivity of key SFE subsystem components on an integrated basis. *An* operational SFE would reduce the annual resupply weight for the international Space Station by 12,000 pounds with an associated reduction in logistics costs.
International Space Welding Experiment (ISWE) Critical Design Review - 2nd Qtr FY 1996	The ISWE will demonstrate the ability to perform contingency repairs to the international Space Station using an electron beam welding device developed by the Paton Institute in the Ukraine.
SFE Flight Demonstration - 1st Qtr FY 1998	This flight demonstration will verify the performance capability of the SFE subsystem in microgravity during the STS-87 mission.
ISWE Flight Demonstration - 1st Qtr FY 1998	The capability of the Ukrainian Hand Tool to be utilized to weld Space Station materials and structure will be demonstrated during the STS-87 mission.

ACCOMPLISHMENTS AND PLANS

Advanced Operations accomplishments in FY 1994 include:

The Miniature Universal Signal Conditioning Amplifier - a component in the Permanent Measurement System at the Kennedy Space Center (KSC) which will result in the savings of approximately 4500 work-hours per year in transducer calibration time or approximately $180.000 per year when implemented. and which is being made available commercially through a joint collaboration of NASA, the State of Florida and private corporation.

The Ground Processing and Scheduling System - a software tool developed to produce and distribute schedules for post-landing/pre-launch processing of the Space Shuttles which is already saving the Space Shuttle support contractor at KSC approximately $400.000 per Space Shuttle mission and which was, in FY 1994. awarded the largest Space Act Award in NASA history for having spawned a new business and for its tremendous potential for commercial application.

The Spacehab Intelligent Familiarization Trainer - an application of the previously-developed Intelligent Computer Aided Trainer which enabled the Spacehab program to avoid over two million dollars in the cost of developing a Spacehab trainer while still providing quality training for Spacehab crews.

The EVA Electronic Cuff Checklist - an electronic replacement for the paper checklists carried by astronauts during space-walks which will, during the Space Station era, reduce the costs of producing and transporting paper procedures for the Station crew and will improve the efficiency of mission operations through improved flexibility, and rapid turnaround and update of procedures.

The Distributed Earth Model and Orbiter System - previously supported by the Advanced Operations Program, and presented the Federal Leadership Award in FY 1994 for having enabled a savings of over $2 million in the cost of a visual orbital display for the Consolidated Control Center at the Johnson Space Center.

In FY 1995 and 1996. the Advanced Operations program will continue to address its goals by supporting projects to enhance the safety of the Space Shuttle and Space Station crews with projects such as a microwave device for tracking space-walking astronauts and a virtual visualization tool for monitoring the final approach of the Space Shuttle to the Mir and the Space Station; projects to reduce costs and improve efficiency such as the Electronic Documentation Project and Advanced Data Management System which will reduce the amount of paper products required for flight and speed the process of document revision, approval, and distribution: projects to improve the monitoring of environmental impacts such as a buoy which optically checks water quality of the rivers around the KSC launch area; projects which encourage academic development in space related fields at the HBCUs such as Environmentally Safe Rechargeable Batteries for Space and Small Portable Mass Spectrometer Development; and projects which have technology transfer potential such as the Payload Guidance Transfer System and the Surface Defect Analyzer.

In the Advanced Space Systems Program, a total of 15 successful flight demonstrations have been conducted. Some examples of recent accomplishments include:

The Fluid Acauisition and Resupply Flight Demonstrations (FARE-11 and [FARE-21. and the Superfluid Helium On-Orbit Transfer (SHOOT) flight demonstration were flown on the Space Shuttle. The FARE flight demonstrations were utilized to obtain essential low gravity fluid transfer data that are applicable to Space Station to increase the efficiency of fluid transfer operations and by the Space Shuttle to increase the safety and efficiency of extended duration flights. The SHOOT flight demonstration not only demonstrated the feasibility of superfluid helium transfers on orbit at operational rates, but it also set the precedent for cryogenic payload safety on both Space Shuttle and Space Station. The hardware, software and operational procedures developed as part of the SHOOT flight demonstration will result in future cost savings to other microgravity payloads. The SHOOT cryogenic hardware components have already become industry standards.

The Small Expendable Deployers [SEDS-1 and SEDS-21 flight demonstrations. and the Plasma Motor/Generator (PMG) flight demonstration were tether applications experiments that were flown as secondary payloads aboard Delta II launch vehicles. The SEDS flight demonstrations proved the technology readiness of these low cost and safe systems which have promising applications for the routine deorbiting of Space Station materials and emergency medical samples as well as the placement of instruments into the upper atmosphere. The SEDS experiments also demonstrated the feasibility of using these low cost tether applications testbeds for improving the efficiency of in-space operations. The PMG flight demonstration proved the ability of the proposed Space Station plasma grounding techniques for maintaining the electrostatic potential between the Space Station and the surrounding plasma medium. The PMG also demonstrated the ability to use electrostatic tethers to provide thrust to offset drag in LEO space systems. The PMG also demonstrated the use of direct magnetic (non-rocket) propulsion for orbital maneuvering. The orbital debris program is directed at measuring the orbital debris environment, developing debris growth mitigation measures, and enhancing spacecraft protection and survivability. A total of 2400 hours of observations of the debris environment reduced the uncertainty in that environment from some 300% to approximately 50%. In addition, the first survey of the orbital debris environment at sun synchronous and geostationary attitudes was initiated. These continuing measurements are the basis for

studying and understanding future orbital debris mitigation measures which will result in lowering the cost of, as well as, improving the safety of the Space Shuttle and the international Space Station. Geostationary orbital debris data is being utilized to develop cost effective debris mitigation techniques to protect vital geostationary assets.

The Advanced Space Systems program will continue to address its stated goals for FY 1996 by supporting projects to enhance the safety and mitigate risk on the Space Shuttle and Space Station with projects such as the Space Station Static Feed Water Electrolysis System (to reduce logistics costs via increased closure of the life support system to generate oxygen), the Ukrainian Universal Hand Tool (to validate the Ukrainian-developed space-based electron beam welding capability for on orbit operations, and the Debris Capture Flight demonstration on Mir (to initiate in-situ environmental measurements in the planned Space Station environment).

BASIS OF FY 1996 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Engineering and technical base	180.400	165,600	171,700

PROGRAM GOALS

The focus of the Engineering and Technical Base (ETB) is to support the institutional capability to operate space flight laboratories, technical facilities, and testbeds: conduct independent safety, and reliability assessments: and to stimulate science and technical competence in the United States. The ETB activities are carried out by the NASA Field Centers at the Johnson Space Center (JSC) including White Sands Test Facility (WSTF).Kennedy Space Center (KSC).Marshall Space Flight Center (MSFC),Stennis Space Center (SSC) and the Office of Space Flight at Headquarters. The ETB provides the underpinning of the Centers' performance of research and analysis and testing tasks, to solve present problems, and to produce benefits to avoid high expenditures in developing programs, technologies, and materials. The ETB empowers a core workforce to perform programs for NASA, other Federal and State agencies, reimbursable customers, commercial entities. and international agencies.

STRATEGY FOR ACHIEVING GOALS

The Office of Space Flight strives to sustain its institutional technical base and preserve a high degree of core capability and excellence. The FY 1994 consolidation of activities identified ways to economize the resources committed to ETB and maintain benefits to the nation's major space flight program. Over the next few fiscal years, the FY 1994 actions will continue to generate savings in information resources management and contract streamlining. A prioritized core environment will be dedicated to multi-program labs and test facilities. associated systems, equipment, and a full range of skills capable of response to research, testing and simulation demands.

Mandatory equipment repair and equipment replacement will be assessed. Software applications for multi-program analytical tools will be implemented. Strategy to better manage the NASA investment in information processing resources will include aggressive actions to integrate and consolidate more ADP operations. ETB will ensure synergism among major NASA engineering programs. Awards for education and research tasks will be granted to support educational excellence and research learning opportunities in colleges and universities. Awards will also be granted to enhance teacher and faculty skills as they provide science, mathematics, engineering and technology education at the elementary, secondary and university levels.

MEASURES OF PERFORMANCE

Laboratory facilities (KSC) Continuing effort	Support 22 labs for approximately 121 applied research projects
Laboratory facilities (JSC) Continuing effort	Support 37 labs including 32 science and engineering and 5 space and life sciences
Laboratory facilities (MSFC) Continuing effort	Support 52 major core laboratory areas
Propulsion Facility and Lab Infrastructure (WSTF) Continuing effort	Core environment to support customer base
Safety and Mission Assurance Analysis - 4th Qtr FY 1995	Validate Independent Assessments
Equipment Replacement Study 4th Qtr FY 1995	Prioritized Replacements and Upgrades
Information Resources Management (IRM) Five Year Investment Plan (MSFC) - 4th Qtr FY 1995	Consolidate Automated Data Processing (ADP) Operations
Best Business Practice Pilot Project (JSC) - 4th Qtr FY 1995	Test the Engineering Technical Analysis contract support to the Shuttle Engineering Simulator (SES) area
IRM Five Year Investment Plan (MSFC) - 4th Qtr FY 1996	Consolidate ADP Operations

ISHMENTS AND ANS

The institutional technical base accomplished numerous activities in FY 1994. The JSC initiated the Best Business Practice pilot project to test the Engineering, Test and Analysis (ETA) contract support to the Shuttle Engineering Simulator (SES) area. The test generated data shows nearly $1 million in savings could be realized over time in the SES area. Benefits of the data will be incorporated in the ETA contract. such as consolidation of fragmented controls, a rebaseline of the negotiated contract value and renegotiated fee plans. The JSC is implementing the pilot in seven other laboratory areas. In addition, the JSC allocated

institutional technical base support to **32** science and engineering and five (5)space and life sciences laboratories. Laboratories prepared the Dual-Technology Flow Meter Testbed for identifying gases in deep-water wellhead: completed repairs on two network analyzers in the Microwave Integrated Circuit Laboratory; designed and fabricated new Source Antenna for use in the Anechoic Chamber, installed three S-Band Space **Loss** Simulator Area Racks in Electronic Systems Test Lab (ESTL); completed analyses of the Prism Stereo Vision, the Perception Laser Mapper and the Complex Object Grasp Test elements of EVA Robotics Helper and Retriever Task provided helium skid support to Chamber using tie lines from Chamber **A** installed and checked out instrumentation in High Temperature Superconductivity Lab, completed Phase **1** test of the Single Dexterous Arm/Hand and Phase **2** Build; Second Dexterous Arm/Hand in the Hand Dexterous Anthropomorphic Robotics Testbed: completed man-rating capability of Chamber **A,** modifying the fire suppression and emergency systems: completed development of Electromagnetic Heart Catheter for Baylor Medical Center application: tested **4** Degree-of-Freedom Correlator in both Optical Tracking Correlator and 6-Degree of Freedom Facility: replaced obsolete liquid nitrogen controls in Chamber A and helium controls in Chamber **B32:** and upgraded the Systems Integrated Research Facility including the Water Recovery System. The ETB also provided the infrastructure for real-time mission support for flight anomalies and real-time and post-flight problem resolutions.

The ETB enabled the WSTF to maintain its propulsion facility and laboratory infrastructure. The WSTF performed maintenance and repair of its test stands, propellant and gas supply distribution systems, safety systems, data acquisition and control systems. The core environment enabled WSTF to support a customer base with testing and evaluations of spacecraft materials, components, propulsion systems for safe human exploration and utilization of space. It enabled WSTF to perform tasks for the Space Shuttle Orbiter, payloads. international Space Station, crew training, engineering and development, other Government agencies such as the Army, Navy. Air Force, Energy, and Transportation. and the aerospace and medical industry.

With ETB funding, the KSC supports a core environment for **22** laboratories for **121** applied research projects. The KSC solved programmatic issues with ETB participation in tasks resulting in a prototype of the air coupled advanced ultrasonic leak detector which located the leakage on the STS-65 flight, documentation of Window #6 micrometeoroid crack on the STS-60 flight, Launch Complex **39 (LC-39)**pad meteorology instrumentation upgrade saved **$1** million first time use, wind profiler instruments for the KSC and the Dryden Flight Research Facility, the first NASA/State of Florida/corporate partnership for technology transfer of the Universal Signal Conditioning Amplifier, and a standardized transducer for all ground support equipment which included 6,000 measurements and **23** transducer types. The ETB enabled the KSC to eliminate potentially critical failures on the KSC fiber optic circuits and assisted the Shuttle Launch Processing System organization in understanding and properly using fiber optics for launch processing. The KSC teamed with the MSFC and SSC to develop the improved hydrogen leak detector and collaborated with the SSC on flame detection systems. The ETB supported upgrades to the **LC-39** measurement system. The ETB also participated in the development of landing aids for a lightning warning and prediction system, toxic vapor detectors and sensors to measure Space Shuttle tile waterproofing compound vapors.

The ETB supported the KSC life sciences tasks. The microbiological lab developed a unique method to functionally characterize microbes in nutrient solutions, soils and surface waters: the chemistry lab researched a process to identify mercury contamination in surface water: and the microscopy lab analyzed the root characteristics of plants grown on flight nutrient delivery systems.

The MSFC allocated the ETB to 52 major core laboratory areas. The ETB support enabled the Center's technical core capability to provide in-depth technical support for designs, developments, testing, mission operations and evaluation of launch vehicles, space transportation systems, space stations. and payloads. The ETB enabled the MSFC to conduct research and development efforts related to engineering design, systems engineering, systems integration, material and process engineering. physical science research, test and evaluation, data analysis and system simulations. Programs benefiting from the core environment were the Space Shuttle Main Engine **(SSME),** Advanced X-ray Astrophysics Facility (AXAF), Solar X-ray Imager (SXI), Alternate Turbopump Development, Redesigned Solid Rocket Motor, international Space Station. Spacelab. Lightning Imager Sensor, Single-Stage-to-Orbit, and Space Station Furnace Facility. Specific accomplishments for the programs include analysis of the **SSME** fuel flowmeter, developed computer program that calculated the aerodynamic forces and moments on subsonic through hypersonic flight vehicles, generated the first geophysical data products for the **Earth** Observing System pathfinder, provided vacuum ultraviolet **flux** calibrations for paint recertification tests, and assessed the suitability of NASA treetops computer code for modeling the structural dynamics and point control of the AXAF-I observing satellite.

The ETB participated in the SSC laboratory maintenance operations. Although the **size** of the SSC institutional engineering capability is very minimal, the ETB enabled the Center to conduct advanced propulsion test technology research and development for government and commercial propulsion programs. The SSC performed laboratory activities for major **NASA** shuttle programs, the Air Force National Aerospace reimbursable program, and Rocketdyne test operations. The SSC core laboratory environment provided customers with gas and material analysis, non-destructive evaluations, standards and calibrations. environmental analysis, fluid component processing, maintenance and fabrication of welded structures and components, and machining and fabrication of mechanical structures and components. The ETB enabled the SSC to complete advanced planning studies involving cost trade presentations for future facility utilization and technology development **tasks** such as the seal configuration tester prototype.

The Research and Development (R&D) hardware fabrication and assembly services benefited programs such **as** the Crystal Growth Furnace, Composite Infrared Spectrograph, international Space Station, Super Lightweight Tank, Geophysical Fluid Flow Cell, Remote Manipulator System, Electromechanical Actuator, Japanese/American Cooperative Emulsion Experiment, Tethered Satellite System, and Advanced Automated Directional Solidification Furnace. Propulsion technicians prepared facilities to conduct testing in the Technology Test Bed, Hydrogen Cold Flow Facility, 4583 Test Cells, Solid Propellant Test Facility, Improved Hot Gas Facility, Test Stand (TS) **115.** TS **116.** TS 300 and TS 500. Over 52.000 items of standards and test equipment were calibrated: instruments were serviced and repaired involving approximately 26 disciplines of mass, force, and temperature. Nearly 25 million units of mission imaging workload were accomplished. Over a thousand Non-Destructive Evaluations were performed by the KSC to support the Space Shuttle and payload processing schedules. The ETB supported over 12,000 units of commodity sampling and an average of 5,000 units of chemical analysis at the KSC on propellants, aircraft fuels and gases. The MSFC purchased predominately liquid nitrogen, the bulk of which was converted to gaseous nitrogen, and was distributed to the various test facilities and laboratories via an underground piping system. Small amounts of liquid oxygen and helium were also procured.

Under the ETB program, NASA empowered the institutional Safety and Mission Assurance (SRM&QA) contracted workforce to perform space flight activities at the JSC. the **WSTF.** the MSFC and the KSC. The workforce are highly skilled personnel who are charged with responsibility to conduct assessments of conformance to reliability and quality standards. The ETB resources also

supports independent assessments of flight and test equipment and testing operations, including product assurance tasks for the international Space Station program. Critical flight systems process training was accomplished. Certifications of pressure systems and contractors were also performed. Surveillance of design manufacturing and testing of hardware and software were conducted to ensure compliance with NASA safety and mission assurance policy. Problem trending, reliability trending and special safety assurance studies were also accomplished.

Information resource management (IRM) processing achieved numerous efficiencies through the consolidation of mainframes at the MSFC and networks at the JSC; merger of the agency telecommunications; reorganization of ADP services and support contracts; consolidation of international Space Station and Space Shuttle user requirements; consolidation of site licenses for personal computer software; standardization of the MSFC data administration plan, central data dictionary and data naming; and standardization of the JSC, MSFC and SSC software and manual development. In FY 1995. the **ETB** will participate in the Office of Space Flight IRM Five Year Investment strategy plan for FY 1995 through **FY** 1999 which will accrue tremendous savings to space flight ADP operations. The IRM savings are expected to be at least 35 percent in the near-term and up to 50 percent in costs in the outyears.

The JSC and the MSFC Engineering Computation Facility (ECF) Class VI Supercomputers operate major systems for engineering and scientific computer-intensive applications seven days a week. The ECF provides the JSC and the MSFC with the ADP hardware and software to conduct thermal radiation analyses, computational fluid dynamics. structural dynamics and stress analyses, certification and engineering performance evaluation of flight and test data, and simulation aerodynamics. The ETB class VI funding supports the efficiency actions identified by the NASA ADP Consolidation Center (NACC) project for FY 1994. The NACC named the MSFC as the consolidation center to house the Class VI operations with the JSC Class VI relocating to MSFC. The ETB will continue to support the NACC Class VI operations in FY 1995. In **FY** 1996, the NACC Class VI operations will be moved to a user fee arrangement and extend the capability to other NASA Centers. The MSFC and the JSC will continue to develop and process software applications under the new fee arrangements.

In cooperation with the goals of the NASA Minority University Research and Education Program, the ETB enabled the space flight Centers to increase participation in programs to stimulate science and technical competence in the nation. The ETB program empowered the Centers to award a total of ***72*** education and research grants to Historically Black Colleges and Universities (HBCU), Other Minority Universities (OMU), Teacher/Faculty enhancement programs, and the JSC University Research Program. Examples of awards granted include supersonic gas-liquid cleaning systems: Houston Preparatory Initiative: Scientific and Technical Instructions Focusing on Pre-College Underrepresented Minorities: Reliability of Damaged Space Structures from Vibration Measurements, and American Associate for Engineering Education Summer Faculty Fellowship Program.

The ETB support to a core engineering environment is planned at the Centers in FY 1996. A full range of workforce skills. analytical tools and facilities is planned to enable space flight institutional engineering to support the NASA programs and a customer base with design, development, test and evaluations. independent assessments, simulation. operations support. anomaly resolution, and systems engineering support. A full range of technical operations support for standards and calibration, non-destructive evaluation. manufacturing and fabrication, sampling and analysis, gas supplies and operations, SRM&QA and independent assessments. Education and research awards will be supported. Actions to eliminate costly duplication of

capabilities is planned. Results of the review of the ETB equipment replacement program should generate a course of actions for upgrades in FY 1996; other reviews such as ETB program-unique tasks performed by the science and engineering labs should also generate a course of action to implement in FY 1996 which may permit realignment of funding resources among the ETB functions.

Science, Aeronautics
and Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

GENERAL STATEMENT

The Science, Aeronautics and Technology appropriation provides funding for the research and development activities of NASA. This includes funds to extend our knowledge of the Earth, its space environment, and the universe; to invest in new aeronautics and advanced space technologies which support the development and application of technologies critical to the economic, scientific and technical competitiveness of the United States. These objectives are achieved through the following elements:

Space Science: This program conducts' a broad spectrum of scientific investigations to advance our knowledge of the sun, the planets, interplanetary and interstellar space, and the stars of our galaxy and the universe.

Life and Microgravity Sciences and Applications: A program to identify and develop the technology for the useful applications of space techniques in the area of materials process research and experimentation, and to explore the effect of the zero-gravity environment of space on human physiology.

Mission to Planet Earth: A program to provide for the use of space systems, supported by ground-based and airborne observations, to acquire information which will assist in the solution of Earth resources and environmental problems.

Aeronautical Research and Technology: **A** program to conduct the fundamental long-term research to strengthen the United States leadership in aviation, and to pursue development of high leverage technologies required to support both the subsonic and high-speed civil transport economic viability.

Space Access and Technology: A program to provide new and innovative space technologies to meet the challenges and lower the cost of future space missions.

Mission Communication Services: Funding for communications activities which are most directly related to NASA's science and aeronautics programs.

Academic Programs: A program to support Agencywide university, minority university, and elementary and secondary school programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY
FISCAL YEAR 1996 BUDGET ESTIMATES
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1994	1995	1996
SCIENCE, AERONAUTICS AND TECHNOLOGY	**5,792.5**	**5,943.6**	**6,006.9**
SPACE SCIENCE	1,920.9	2,012.6	1,958.9
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	507.5	483.1	504.0
MISSION TO PLANET EARTH	1,068.0	1,340.1	1,341.1
AERONAUTICAL RESEARCH AND TECHNOLOGY	1,067.2	882.0	917.3
SPACE ACCESS AND TECHNOLOGY	562.4	642.4	705.6
MISSION COMMUNICATION SERVICES	581.0	481.2	461.3
ACADEMIC PROGRAMS	85.5	102.2	118.7

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

SCIENCE, AERONAUTICS *AND* TECHNOLOGY

(INCLUDING RESCISSION OF FUNDS)

For necessary expenses, not otherwise provided for, for the conduct and support of science, aeronautics, and technology research and development activities, including research; development; operations; services; maintenance; construction of facilities including repair, rehabilitation and modification of real and personal property, and acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft; [$5,901,200,000] *$6,006,900,000*, to remain available until September 30, [1996] *1997*.

[Of the amounts provided under the heading, "CONSTRUCTION OF FACILITIES", for the Consortium for International Earth Science Information Network in Public Law 102—389, $10,000,000 are rescinded.] *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1995.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY
REIMBURSABLE SUMMARY
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1994	1995	1996
SCIENCE, AERONAUTICS AND TECHNOLOGY	**568.1**	**618.9**	**618.7**
SPACE SCIENCE	70.2	82.8	87.6
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	0.5	1.3	1.4
MISSION TO PLANET EARTH	227.8	281.5	278.8
AERONAUTICAL RESEARCH AND TECHNOLOGY	102.6	84.7	88.7
SPACE ACCESS AND TECHNOLOGY	156.7	152.0	154.2
MISSION COMMUNICATION SERVICES	10.0	10.9	7.0
ACADEMIC PROGRAMS	0.3	5.7	1.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1996 ESTIMATES

DISTRIBUTION OF SCIENCE, AERONAUTICS AND TECHNOLOGY BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Space Station Program Office	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Space Science	1994	1,920,900	4,604	0	320	314,876	0	40,412	0	65	129,380	696,483	469,554	265,206
	1995	2,012,600	4,532	0	1,325	331,763	0	37,839	0	900	103,890	755,003	513,820	263,528
	1996	1,958,900	4,329	0	3,311	317,746	0	75,419	0	500	97,457	695.698	523,711	240,729
Life and Microgravity Sciences and Applications	1994	507,500	130,800	0	27,900	122,000	0	66,600	0	7,200	74,400	500	16,200	61,900
	1995	483,100	98,300	0	20,900	112,000	0	63,500	0	800	75,900	0	2,500	109,200
	1996	504,000	108,900	0	19,400	125,200	0	71,800	0	3,600	82,700	300	8,000	84,100
Mission to Planet Earth	1994	1,068,000	167	0	75	12,904	80	37,723	0	31,720	19,103	747,075	105,055	114,098
	1995	1,340,100	0	0	100	8,600	500	37,400	0	60,600	40,600	836,000	204,900	151,400
	1996	1,341,100	0	0	100	9,600	400	33,900	0	48,800	66,300	883,400	157,100	141,500
Aeronautical Research and Technology	1994	993,200	600	0	0	800	500	262,700	51,700	363,100	258,300	18,500	9,400	27,600
	1995	882,000	400	0	0	700	200	234,800	48,900	305,500	243,700	25,300	5,600	16,900
	1996	917,300	100	0	0	200	0	246,900	45,800	331,700	247,300	21,300	5,600	18,400
Undistributed: Construction of Facilities - Various locations	1994	74,000												
	1995	0												
	1996	0												
Total Aeronautical Research and Technology	1994	1,067,200												
	1995	882,000												
	1996	917,300												
Space Access and Technology	1994	562,400	93,900	0	11,500	63,500	9,000	25,300	0	39,200	73,200	39,300	61,400	146,100
	1995	642,400	23,700	0	15,900	145,200	14,000	31,600	300	55,400	59,000	55,700	69,000	172,600
	1996	705,600	32,800	0	17,200	175,500	18,000	33,900	200	79,400	87,400	61,900	80,500	118,800
Mission Communication Services	1994	580,981	50	0	0	2,500	0	14,300	0	0	1,397	322,113	215,159	25,462
	1995	481,200	0	0	0	3,000	0	16,600	0	0	1,800	260,400	176,700	22,700
	1996	461,300	0	0	0	3,000	0	13,900	0	0	1,900	240,700	178,300	23,500
Academic Programs	1994	85,500	960	0	245	2,309	979	721	0	2,679	1,687	1,340	1,884	72,696
	1995	102,200	1,420	0	699	2,513	1,220	1,295	0	2,844	2,387	1,637	2,056	86,129
	1996	118,700	1,597	0	860	2,801	1,449	1,656	0	3,033	2,665	1,829	2,262	100,548
TOTAL SCIENCE, AERONAUTICS AND TECHNOLOGY	1994	5,792,481	231,081	0	40,040	518,889	10,559	447,756	51,700	443,964	557,467	1,825,311	878,652	713,062
	1995	5,943,600	128,352	0	38,924	603,776	15,920	423,034	49,200	426,044	527,277	1,934,040	974,576	822,457
	1996	6,006,900	147,726	0	40,871	634,047	19,849	477,475	46,000	467,033	585,722	1,905,127	955,473	727,577

Science

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995	FY 1996	Page Number
		(Thousands of Dollars)		
Physics and Astronomy	1,149,000	1,195,500	1.131,100	SAT 1.1-1
Planetary Exploration	771,900	817,100	827,800	SAT 1.2-1
Total	1,920,900	2,012,600	1,958,900	

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

OFFICE OF SPACE SCIENCE

PROGRAM GOALS

Humans have been continually driven by a profound curiosity to discover and understand our origins, our existence and our fate. For millennia, humans have gazed at the sky, observed the motions of the of the Sun, Moon, planets and stars, and wondered about the universe and how we are connected to it. The remarkable discoveries made by scientists over the years, which have revealed many intricate workings of the natural world, have been largely unexpected. The quest for knowledge and understanding about the universe in which we live send us to its farthest reaches, to continually explore and search for more answers.

The mission of the Office of Space Science is to seek answers to fundamental questions about :

The Galaxy and the Universe - What is the universe? How did it come into being? How does it work? What is its ultimate fate?

The Connection between the Sun, Earth, and Heliosphere - How does the Sun influence Earth and the rest of the solar system? What causes solar variability?

The Origin and Evolution of Planetary Systems - What was the origin of the Sun, the Earth, and the planets, and how did they evolve? Are there worlds around other stars? What are the ultimate fates of planetary systems?

The Origin and Distribution of Life in the Universe - How did life on Earth arise? Did life arise elsewhere in the universe?

Throughout its history, the accomplishments of Space Science program have rewritten textbooks. The ultimate beneficiary of this program of exploration is the American public. Communicating the benefits of the Space Science program to the American public is an underlying goal in all the activities of the Space Science programs.

STRATEGY FOR ACHIEVING GOALS

Science strives to find objective answers to the questions raised above through observation, development of theories and hypotheses, experimental tests of ideas, and discovery. The Space Science program uses exploration to acquire knowledge and make discoveries. We explore physically, by means of space probes and planetary landers and orbiters, and we explore remotely, by means of telescopes and other observatories in Earth or heliocentric orbit that observe the Sun, the solar system, and the distant universe. Each scientific area to be addressed follows the same path, leading from definition of the specific questions to be answered, design, development and conduct of new experiments to address new questions, analysis, interpretation, and

dissemination of the results of these experiments, and finally, employing the new knowledge to frame new scientific questions. Each major Space Science program element is structured to follow that path.

The past several years have been one of tremendous change in the Space Science program. The significant budget growth experienced from 1986 through 1991 was driven by the approval of several new large programs. Since 1992, the budget expectations for NASA budget have been reduced drastically, and **has** forced a major upheaval in all of the ongoing programs within the Space Science program, to rescope these activities to fit within a much tighter funding envelope. The Cassini mission to Saturn was restructured to significantly reduce the peak funding requirements and life cycle cost of the mission, but simplifying the spacecraft, reducing mission operations costs, and trimming science requirements. The Advanced X-ray Astrophysics Facility *(AXAF)*, the third of the four great observatories, has been significantly descoped to an imaging mission, and operations costs were reduced by eliminating on-orbit servicing of the spacecraft and planning for a shorter operational lifetime.

This changing environment has fundamentally altered the way the Space Science plans its missions. Planning is now for smaller, less expensive missions requiring shorter development times. The Mars Surveyor program, designed to achieve the lost Mars Observer science objectives, provides a more robust approach, distributing risk with two launches per opportunity using small orbiters to recover global orbital survey objectives and an evolutionary series of small, inexpensive landers to meet landed science objectives. The Discovery program, will carry out small focused solar system exploration missions, that can be launched within three years of initiation for a cost of no more than $150 million (FY 1992 dollars) including the launch vehicle. Another key in adapting to this new environment has been to reengineer mission operations. The emphasis is on efficient, innovative approaches to achieve more autonomous, less labor-intensive operations.

The key to a robust Space Science Program in the future is a major investment in new technologies to reduce launch costs through the reduction of spacecraft mass, and to reduce total life cycle costs through enhanced effectiveness. Investments in new technologies will permit major scientific advances to be made with smaller, more focused, and less costly missions. A major new initiative, the New Millennium Spacecraft, is underway to aggressively push the development of technologies which will result in spacecraft and instruments a fraction of their current size, yet accomplishing world-class science. The New Millennium Spacecraft program involves participation by a number of program offices within NASA, who will identify key technologies for development as well as test the results with specific science missions. The result of this initiative will ensure that opportunities for exploration continue, maintaining NASA's excellence in Space Science.

Physics and Astronomy

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL *YEAR* 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE **PHYSICS AND ASTRONOMY**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	Page Number
* Advanced x-ray astrophysics facility	239,300	234.300	237,600	SAT 1.1-7
** Gravity probe-b	42.400	50.000	51,500	SAT 1.1-11
** Offsetting reduction	--	--	-51.500	
* Global geospace science	27.600	40,000	5.400	SAT 1.1-14
Payload and instrument development	59,500	53,900	33.100	SAT 1.1-16
Explorers	123.300	120,400	129,200	SAT 1.1-20
Mission operations and data analysis	405,200	432,400	428.600	SAT 1.1-25
Research and analysis	71.100	75.400	90.400	SAT 1.1-30
Suborbital program	69.500	67.200	106.700	SAT 1.1-34
Information systems..	26,500	26.100	25.900	SAT 1.1-39
Launch services	84.600	95.800	74.200	SAT 1.1-42
Total	1,149,000	1.195.500	1.131.100	

* Total Cost information is provided in the Special Issues section

** In October 1994. NASA requested that the National Academy of Sciences (NAS) assemble a review panel to validate the technical feasibility and scientific merits of Gravity Probe-B (GP-B) relative to other science priorities within the NASA budget. Discussions are currently underway, with final results anticipated in mid-1995. In the event the panel recommends continuation of GP-B, equivalent offsets within the NASA budget must be identified.

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL *YEAR* 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE **PHYSICS AND ASTRONOMY**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Distribution of Program Amount bv Installation			
Johnson Space Center	13	27	--
Kennedy Space Center	300	800	500
Marshall Space Flight Center	314.846	331.763	317,746
Ames Research Center	29.473	27,883	65,739
Langley Research Center	40	900	500
Lewis Research Center	42,900	25.700	--
Goddard Space Flight Center	641,588	677.673	622,830
Jet Propulsion Laboratory	41,468	32.928	57.731
Headquarte	78.372	97,826	66.054
To	1.149.000	1.195.500	1.131.100

PROGRAM GOALS

The Physics and Astronomy program seeks to expand our understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of stars and planets. The exploration and research activities of this program seek to answer more specific questions within the four fundamental areas identified as goals of the Space Science program. These more specific areas are:

- Determine the fundamental laws of physics using the unique environment of space:
- Determine the processes that drive the Sun and govern its effects on Earth's environment and the heliosphere;
- Discover the origin, evolution and fate of the universe, galaxies, stars and planets.

STRATEGY FOR VING GOALS

The Physics and Astronomy program is composed of two major elements: astrophysics and space physics. The astrophysics program is concerned with the origin and evolution of the universe beyond our solar system. Objects studied by the astrophysics program include distant galaxies and galactic clusters, as well as stars and other structures in nearby galaxies and the interstellar medium in our own galaxy. Unusual and exotic phenomena -- such as quasars, neutron stars, pulsars. and black holes -- are of particular interest to the astrophysics program, and are the target of many ground-based and space-based research programs. Astronomical observations from space avoids image distortion created by the Earth's atmosphere. Many wavelengths are obscured and some wavelengths cannot be observed from the surface of the Earth at all.

The space physics program is focused upon naturally occurring plasmas, the physical state which comprises 99 percent of all matter in the universe. Relatively cool plasmas in the planetary ionospheres, the hot plasma of the sun, Earth's and other planets' magnetospheres, and galactic cosmic-ray plasmas are all the focus of study. Study of Earth's nearby space environment has revealed a dynamic and complex system of plasmas interacting with the magnetic fields and electric currents surrounding our planet. This region, comprised of the magnetized solar-wind plasma plus the perturbation in the heliosphere caused by the presence of the magnetic Earth, is referred to as geospace.

The goals of the Physics and Astronomy program are achieved through a combination of spacecraft missions, instruments and payloads flown on international and U.S.-sponsored satellites and Shuttle/Spacelab flights, and suborbital missions flown aboard research aircraft, balloons and sounding rockets. The entire program rests on a solid basis of supporting research and technology,

data analysis, and theory programs designed to fully exploit the data obtained and to foster the next generation of space scientists.

With its unprecedented capabilities in energy coverage, spatial resolution, spectral resolution and sensitivity, the AXAF mission will provide unique and crucial information on the nature of objects ranging from nearby stars like our sun to quasars at the edge of the observable universe. The AXAF, initiated in FY 1989, has been significantly restructured, and is scheduled to be launched with an upper stage by the Shuttle in September 1998 for a five-year mission. AXAF will provide high resolution imaging of the x-ray spectrum, which is necessary for both the discovery and subsequent investigation of various energetic phenomena associated with galaxies, stars, neutron stars, black holes, and interstellar material.

Full scale development of the Gravity Probe-B mission was initiated in FY 1993 after a lengthy period of science definition, technology demonstration, and design and test of prototype components.. This is a highly complex, technically challenging mission designed to test key elements of Einstein's General Theory of Relativity. The mission will explore the predictions of the theory in two areas: (1) A measurement of the "dragging of space" by rotating matter; and, (2) A measurement of space time curvature known as the "geodetic effect". The mission is baselined for launch in October 2000 aboard a Delta launch vehicle. In October 1994, NASA requested that the National Academy of Sciences (NAS) assemble a review panel to validate the technical feasibility and scientific merits of the mission in light of other science priorities within the NASA budget. Discussions are currently underway, with final results anticipated in June 1995. In the event the panel recommends continuation of the GP-B mission, equivalent offsets within the NASA budget must be identified.

The Global Geospace Science (GGS) program is part of the U S . contribution to the International Solar Terrestrial Physics (ISTP) program designed to conduct advanced observations and study of the sun and Earth's geospace. NASA's two GGS spacecraft, Wind and Polar, together with Japan's Geotail (launched in 1992) and other Earth observing and near-Earth satellites, will make the first coordinated geospace measurements of the interaction between the Earth's magnetic field and plasma from the sun, and the transfer of mass, energy, and heat to the Earth system. Wind will study this transfer at the head of the geospace region which lies between the Earth and the Sun. Polar will conduct at Earth's poles, and Geotail at a point where the Earth's magnetic region tails away. Wind was successfully launched in November 1994; Polar is scheduled for launch in December 1995.

Physics and Astronomy Payload and Instrument Development supports a number of instruments and payloads to be used on international satellites or on Spacelab missions. The Collaborative Solar-Terrestrial Physics (COSTR) program is the other U.S. contribution (with the GGS program) to the International Solar Terrestrial Physics (ISTP) program. The COSTR program is providing instruments and subsystems for ISTP missions developed by our international partners, including the European Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft, with launches scheduled for October and December 1995, respectively. The Japanese Geotail spacecraft was launched successfully in 1992 and is currently in operation. Payload and Instrument Development also includes the Tethered Satellite System (TSS) science program; TSS is a cooperative program with Italy that will contribute to our knowledge about geospace. Launch aboard the Shuttle is scheduled for February 1996.

The Explorer program supports the development of small to moderate-sized astrophysics and space physics missions. The types of missions selected conduct investigations of an exploratory or survey nature, or have specific objectives that do not require the capabilities of a large spacecraft or observatory. Missions currently under development include the X-ray Timing Explorer (XTE)

and the Advanced Composition Explorer (ACE).with planned launches in August 1995 and late 1997, respectively. Each mission will be launched aboard a Delta launch vehicle. The Small Explorer (SMEX) program supports smaller, lower-cost missions with more focused science objectives which can be flown aboard a Pegasus launch vehicle. SMEX missions currently under development are the Submillimeter Wave Satellite (SWAS) and the Fast Auroral Snapshot (FAST),both planned for launch in mid-1995. Two new missions selected for development beginning in FY 1995 are the Transition Region and Coronal Explorer (TRACE) and the Wide-field Infrared Explorer (WIRE), with planned launches in 1997 and 1998, respectively.

The Mission Operations and Data Analysis program supports satellite operations during the performance of the core missions of spacecraft, extended operations of selected spacecraft, and for ongoing analysis of data after the usable life of a spacecraft has expired. Funding is also provided for pre-flight preparations for NASA satellite operations and data analysis activities, and for long-term data archiving and data base services. In addition, funds from this category are used to support ongoing servicing support and new instrument development for the Hubble Space Telescope (HST). The HST Space Telescope Imaging Spectrograph (STIS) and Near Infrared Camera and Multi-object Spectrometer (NICMOS) are being developed for flight in 1997, and the Advanced Camera for flight in 1999.

The Suborbital program uses aircraft, balloons, and sounding rockets to conduct versatile. relatively low-cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and international cooperative basis. Funds are requested beginning in FY 1996 to initiate development of the Stratospheric Observatory for Infrared Astronomy (SOFIA), a cooperative program with Germany that will replace the aging Kuiper Airborne Observatory (KAO). SOFIA will accomplish infrared studies of the birth and death of stars. formation of planetary systems, chemical make-up of star-forming clouds in the Milky Way galaxy. nature of the energy sources in other galaxies. and nature of the outer bodies in our own solar system. Initial operations are scheduled for FY 2000.

The Research and Analysis program provides a solid basis of supporting research and new technology development, research, and theory-building. Research teams at NASA centers and at universities, industrial laboratories, and other government laboratories are supported. The scientific information obtained and the technology developed in this program are made available to the scientific communities and the general public for application to the advancement of scientific knowledge. education and technology. Funds are also requested in FY 1996 for planning and technology development activities related to the Space Infrared Telescope Facility (SIRTF). SIRTF is the last of the four Great Observatories and has been the highest priority new mission in astrophysics for many years. SIRTF will perform science that is complementary to SOFIA, and may include a collaboration with the Japanese to achieve a portion of its science objectives. Development is planned to begin in FY 1997, with a planned launch in FY 2002.

The Information Systems program in Physics and Astronomy will provide a state-of-the-art computer and data environment to support science research objectives. This includes high performance networking and computing, with expedient access to data, mathematical processing tools, and advanced visualization techniques to convert massive amounts of data to meaningful information. leading to improved scientific insight. Multiple science disciplines will be supported by the projects funded under this program.

Beginning in FY 1996, mission unique launch services for all Space Science missions requiring expendable launch vehicles are included as part of the OSS budget. Overall program management rests with NASA's Launch Vehicles Office (LVO). Launch services funding budgeted within OSS supports Pegasus launch services for the SMEX missions (FAST, SWAS, TRACE, WIRE); Medium-lite class launch services for FUSE; Delta launch services for GGS (Wind, Polar), Explorers (ACE, XTE); Atlas launch services for SOHO; and an Inertial Upper Stage (IUS) for AXAF.

BASIS OF FY 1996 FUNDING REQUIREMENT

ADVANCED X-RAY OPHYSICS FACILIT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Advanced x-ray astrophysics facility development*.....	239.300	234,300	237,600

* Total Cost information is provided in the Special Issues section

PROGRAM GOALS

The Advanced X-ray Astrophysics Facility (AXAF) will observe matter at the extremes of temperature, density and energy content. Previous x-ray missions such as the Small Astronomical Satellite-C and the Einstein Observatory have demonstrated that observations in the x-ray band provide a powerful probe into the physical conditions of a wide range of astrophysical systems. With its unprecedented capabilities in energy coverage, spatial resolution. spectral resolution and sensitivity, AXAF will provide unique and crucial information on the nature of objects ranging from nearby stars like our sun to quasars at the edge of the observable universe. AXAF is the third of NASA's Great Observatories, which include the Hubble Space Telescope and the Compton Gamma Ray Observatory, and has been given high priority by the National Academy of Sciences Astronomy Survey Committee.

STRATEGY FOR ACHIEVING GOALS

The Marshall Space Flight Center (MSFC) was assigned responsibility for managing the AXAF Project in 1978 as a successor to the High Energy Astrophysics Observatory (HEAO) program. The scientific payload was selected through an Announcement of Opportunity (AO) in 1985 and confirmed for flight readiness in 1989. TRW was selected as prime spacecraft contractor for the mission, with major subcontracts to Hughes Danbury (mirror development), Eastman Kodak (High Resolution Mirror Assembly -- HRMA), and Ball Aerospace (Science Instrument Module - SIM). The Smithsonian Astrophysical Observatory (SAO) also has significant involvement throughout the program. AXAF will be launched on the Shuttle with an Inertial Upper Stage (IUS) provided by Boeing. International contributions are being made by the Netherlands (an instrument), Germany (an instrument). Italy (detector test facilities), and the United Kingdom (microchannel plates and science support).

AXAF was given new start approval in FY 1989. with full scale development contingent upon demonstrating the challenging advances in mirror metrology and polishing technology. The first pair of mirrors were fabricated and tested in a specially designed X-ray Calibration Facility at MSFC in 1991. and the x-ray results validated the polishing and metrology. With the success of this Verification Engineering Test Article (VETA) # 1 demonstration. the program proceeded fully into design and development (Phase C/D).

The AXAF program was restructured in 1992 in response to downward revisions of the future funding projections for NASA programs. The original baseline was an observatory with six mirror pairs that was planned for a 15 year mission in low Earth orbit with shuttle servicing. The restructuring produced AXAF-I, an observatory with four mirror pairs to be launched into a high Earth orbit for a five year life time, and ***AXAF-S.*** a smaller observatory flying an X-Ray Spectrometer (XRS). A panel from the National Academy of Sciences (NAS) endorsed the restructured ***AXAF*** program. The FY 1994 AXAF budget was reduced by Congress, resulting in termination of the ***AXAF-S*** mission. The Committees further directed that residual FY 1994 ***AXAF-S*** funds be applied towards development of a similar instrument payload on the Japanese Astro-E mission to mitigate the science impact of losing ***AXAF-S.*** This activity is currently underway, and funding for FY 1996 Astro-E activities is being requested within the Physics and Astronomy Payload and Instrument Development line.

MEASURES OF PERFORMANCE

HRMA Critical Design Audit (CDA) - February 1994	Review determined that HRMA design is sufficiently mature, with adequate number of detailed drawings completed and meets all critical performance and interface requirements. ***All*** technical problems or design anomalies were resolved without compromising system performance. reliability, safety or resource constraints.
Observatory Preliminary Design Review (PDR) - December 1994	Review confirmed that overall system design is of sufficient maturity, meets all critical technical and performance requirements, established the compatibility of all major hardware interfaces and represents an acceptable level of technical. cost and schedule risk to the program.
Instrument CDRs - April 1995	Reviews will confirm that instrument designs are sufficiently mature, meet all critical performance and interface requirements, and impose acceptable levels of technical, cost and schedule risk to the overall program.
AXAF Science Center (ASC) Critical Design Review (CDR) - July 1995	Review will validate overall maturity of ASC design, ensure that all major hardware and software components adequately support science requirements, and are functionally compatible with all other elements of the ground system.
AXAF Spacecraft Electronic & Structure CDA - December 1995	Review will verify that detailed design of key spacecraft subsystems are sufficiently mature and are physically and functionally compatible with established interfaces and performance criteria of overall spacecraft design.
AXAF Observatory CDR - February 1996	Major milestone. Assess validity and maturity of observatory design **as a** functionally integrated system in terms of subsystem compatibility. interface requirements and ability to meet all established performance criteria within acceptable levels of technical, cost and schedule risk.

Science Instrument Module (SIM) completed - April 1996	Fabrication of the Science Instrument Module completed at Ball Aerospace. The SIM will house the two focal plane science instruments on AXAF, and must be completed prior to delivery of flight instruments.
Deliver flight instruments to Ball - August 1996	Flight instruments shipped to Ball Aerospace upon completion of integration and test activities for integration into SIM (see above).
X-ray calibration tests at MSFC - January 1997	HRMA and SIM hardware shipped to MSFC and integrated into X-Ray Calibration Facility (XRCF) in late 1996. Tests will verify HRMA mirror alignment and compare technical performance of mirrors and science instruments against predicted values.
Begin Observatory assembly and test - October 1997	Initiate integration of completed spacecraft with telescope/instruments at TRW, followed by full-up systems testing (thermal-vac, acoustic, et al).
Deliver Observatory to Kennedy Space Center (KSC) - June 1998	Observatory integration and systems testing completed at TRW. Begin integration with upper stage, final performance testing, and integration in Shuttle cargo bay.
Launch Observatory - September 1998	Shuttle deployment into low-Earth orbit followed by Upper stage delivery to highly elliptical operational orbit. Hardware checkout followed by initiation of science Observations.

ACCOMPLISHMENTS AND PLANS

Recent progress has been extremely positive. Over the past year, AXAF did not lose a day of schedule on the critical path towards launch. Detailed performance predictions based on test and analysis of the mirrors in fabrication and materials and designs of the mirror assembly indicate that performance margins have increased dramatically over the past year. Finally, the upper stage selected provides highly elliptical (10,000 x 140,000 kilometer) orbit, which should increase by over twenty percent the number of observations *AXAF* can make in its operational lifetime.

The Observatory PDR was held in December 1994, with no significant problems identified. Mirror development work at Hughes-Danbury Optical Systems (HDOS) has been completed four months early: all mirrors will be shipped to Optical Coating Laboratories, Inc. (OCLI) for coating as soon as required. The mirrors were delivered earlier than expected and with better than expected smoothness, due to technological and process innovations developed at HDOS.

Detailed design activities will continue throughout FY 1995 in support of planned CDRs for instruments and various elements of the spacecraft and telescope assembly. Mirror fabrication at HDOS will be completed by mid-year, and all mirrors delivered to OCLI by late 1995. The first coated mirror is scheduled to be shipped to Kodak to begin integration into the HRMA in June, but

efforts are underway to accelerate that date to try to build up additional schedule margin. The Alignment Tower for the High Resolution Mirror Assembly (HRMA) at Eastman-Kodak is operational, and engineering tests using an uncoated flight mirror were begun in November.

With the funds requested for FY 1996. AXAF-I development will be more than 80% complete. The spacecraft Structural Test Article will be completed early in FY 1996, and static testing is scheduled to be completed in the middle of the fiscal year. Detailed design activities for the spacecraft should be completed early in FY 1996. and fabrication of the flight structure will begin. The spacecraft CDR is scheduled for February 1996. Development of the HRMA, optical bench, and science instruments will continue in FY 1996, with deliveries of these items for testing occurring over the last half of the calendar year.

BASIS OF FY 1996 FUNDING REQUIREMENT

GRAVITY PROBE-B

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Gravity probe-b development*.....	42.400	. 50.000	51,500

* Total Cost information is provided in the Special Issues section

PROGRAM GOALS

The purpose of the GP-B mission is to verify Einstein's theory of general relativity. This is the most accepted theory of gravitation and of the large scale structure of the Universe. General relativity is a cornerstone of our understanding of the physical world, and consequently our interpretation of observed phenomena. However, it has only been tested in a limited number of ways. An experiment is needed to more precisely explore the predictions of the theory in two areas: (1) A measurement of the "dragging of space" by rotating matter: and, (2) A measurement of space time curvature known as the "geodetic effect". The former (1) has never been measured and the latter: (2) needs to be measured more precisely. Whether the experiment confirms or contradicts Einstein's theory, its results will be of the highest scientific importance. The measurements of both the geodetic and frame dragging effects will allow Einstein's Theory to be either rejected or given greater credence. The effect of invalidating Einstein's theory would be profound, and would call for major revisions of our concepts of physics and cosmology.

The advanced technologies required for GP-B are also relevant to meeting the goals of the Space Technology Enterprise of the NASA strategic plan. GP-B is contributing to the development of cutting-edge space technologies which are also applicable to future space science missions and transportation systems.

STRATEGY FOR ACHIEVING GOALS

This test of the general theory requires advanced applications in superconductivity, magnetic shielding, precision manufacturing. spacecraft control mechanisms, and cryogenics. The GP-B spacecraft will employ super-precise quartz gyroscopes (small quartz spheres machined to an atomic level of smoothness): coated with a super-thin film of superconducting material (needed to be able to "read-out" changes in the direction of spin of the gyros): encased in a ultra-low magnetic-shielded, supercooled environment (requiring a complex process of lead-shielding, a Dewar containing supercooled helium, and a sophisticated interface among the instrument's telescope, the shielded instrument probe, and the Dewar): and maintained with a level of instantaneous pointing accuracy of 20 milliarcseconds (requiring precise star-tracking, a "drag free" spacecraft control system, and micro-precision thrusters). The combination of these technologies will enable GP-B to measure: (1) the distortion caused by the movement of the

Earth's gravitational field as the Earth rotates west to east; and, (2)the distortion caused by the movement of the GP-B spacecraft through the Earth's gravitational field south to north, to a level of precision of 0.2 milliarcsecond per year, the width of a human hair observed from 50 miles.

The expertise to design, build and test GP-B, as well as the detailed understanding of the requirements for the Dewar and spacecraft, resides at Stanford University in Palo Alto, CA. Consequently, MSFC has assigned responsibility for experiment management, design, and hardware performance to Stanford. Science experiment hardware development (probe, gyros, dewar, et al) is conducted at Stanford in collaboration with Lockheed/Palo Alto Research Laboratory (LPARL). Spacecraft development and systems integration will be performed by Lockheed Missiles and Space Corporation (LMSC). Launch is scheduled for October 2000 aboard a Delta 11launch vehicle.

MEASURES OF PERFORMANCE

Probe C PDR - July 1994	Probe C is flight model of container that interfaces the science instrument with the Dewar, carrying plumbing, electronic, and data links, out of the Dewar. Design review verified incorporation of modifications derived from Probe B prototype, verified that overall design meets all established interface and performance requirements.
Probe B delivery - August 1994	Completed final integration and test of prototype probe assembly. Integrated with engineering model dewar for performance testing (Ground Test-1A).
Ground Tests - 1A Start - February 1995	Tests the operation of Probe-B protoflight model of the science instrument under cryogenic conditions to validate operations procedures and evaluate overall systems performance.
Probe C CDR - July 1995	Confirms that design is of sufficient maturity and detail, and is compatible with established interfaces (thermal, structural, etc.). Freezes design prior to initiation of full-scale hardware fabrication.
Spacecraft PDR - November 1995	LMSC-developed spacecraft bus will house the Dewar, Probe, and Science Instrument. Review will determine overall maturity of design, assuring that all critical interfaces and performance criteria have been met. Successful completion will initiate detailed design activities at the subsystem level.
Science Instrument Assembly (SIA) Preliminary Design Review (PDR) - January 1996	SIA is quartz block that houses the quartz gyros, proof mass, electronic pickup sensors, and supporting mechanisms. Review will assess overall design maturity. compatibility with established interfaces, and ability to achieve critical performance requirements.

Flight Model Dewar Delivery - November 1996	Delivery of the largest Helium Dewar ever made for a science mission. Ready for integration with Probe B prototype for second series of performance tests.
Ground Tests-2 start - June 1997	Conduct second series of performance tests using flight model dewar and Probe B prototype.
Probe C delivery - September 1997	Complete integration and test of flight model.
Spacecraft CDR - October 1997	Verify that detailed design of spacecraft bus meets all critical interface and performance requirements. with acceptable levels of technical and programmatic risk Successful completion freezes design and initiates hardware fabrication phase.
Payload/Spacecraft integration - October 1999	SIA shipped to LMSC for integration with spacecraft bus. Initiate system-level testing to verify flight performance.
Ship to KSC - June 2000	Complete flight verification testing. Begin integration with launch vehicle.
Launch - October 2000	Development phase complete. Initiate mission operations phase.

ACCOMPLISHMENTS AND PLANS

Recent activities continue on or ahead of the baseline schedule to launch Gravity Probe-B by October 2000. The telescope Requirements Review and Hardware Preliminary Design Review (PDR) were completed in May 1994. two months ahead of schedule. The Probe-C PDR was completed in July, two months ahead of schedule. Welding of the flight Dewar was recently performed using an automated process: this is the largest spacecraft Dewar ever to be manufactured.

Preparation for the second series of cryogenic ground tests are scheduled to begin in February 1995. These tests will integrate the recently delivered Probe'B prototype with the engineering model dewar to simulate operations in a simulated flight environment. CDRs are scheduled for the telescope assembly and the Probe C (flight model) in mid-1995. and detailed design activities will continue at LMSC in preparation for a spacecraft PDR in November.

In October 1994, NASA requested that the National Academy of Sciences (NAS) assemble a review panel to validate the technical feasibility and scientific merits of the mission relative to other science priorities within the NASA budget. Discussions are currently underway, with final results anticipated in mid-1995. In the event the panel recommends continuation of the GP-B mission, equivalent offsets within the NASA budget must be identified in order to support the program in FY 1996 and beyond.

BASIS OF FY 1996 FUNDING REQUIREMENT

GLOBAL GEOSPACE SCIENCE

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Global geospace science development*.....	27.600	40.000	5,400

* Total Cost information is provided in the Special Issues section

I AI

Global Geospace Science (GGS) is part of the United States' contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a new and comprehensive understanding of the interaction between the sun and the Earth. GGS will allow the United States to become a full partner in the ISTP program, reinforcing our commitments to international cooperation and maintaining a leadership role in solar-terrestrial physics.

ATE FOR ACHIEVING GOALS

GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program under which NASA provides instruments and launch support in exchange for access to science data in a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The combined ISTP program will include eight spacecraft: two U.S. spacecraft, Wind and Polar; five ESA spacecraft, including the Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft; and one ISAS spacecraft, Geotail. Launch of this suite of systems began in 1992 with the successful launch of Geotail and will be completed by late 1995.

The GGS spacecraft will combine their measurements with the Geotail satellite and other Earth Observing Satellites as the first phase of the ISTP program. The two U.S. spacecraft, Wind and Polar, will use a total of nineteen instruments to make simultaneous measures of the interaction of the solar wind with the Earth's magnetic field, both at the head of the field and as the field surrounds the Earth. GGS will provide the first coordinated geospace measurements of these key plasma source and storage regions, perform multi-spectral global auroral imaging, and provide multi-point study of the Earth's magnetic response to the solar wind. The GGS mission will enhance understanding of how energy and matter from the sun influences Earth's geospace and atmosphere, contributing to assessments of the relationship of the sun to the Earth's climate. GGS spacecraft contract award was completed in FY 1989, as was final confirmation and initiation of instrument development activity. Wind was successfully launched in November 1994; Polar launch is scheduled for December 1995.

MEASURES OF PERFORMANCE

Polar Integration and Test (I&T) standdown - May 1994	Halted integration and test activities on Polar, pending successful launch and checkout of Wind to assure spacecraft functionality
Wind launch - November 1994	Development phase complete. Initial spacecraft checkout followed by initiation of mission operations phase.
Polar Thermal - Vacuum Test - March 1995	Conduct critical performance testing of fully integrated spacecraft (with instruments) with fully operational flight software in a simulated space environment.
Polar Validation & Verification (V&V) test - Part 1 - August 1995 Part 2 - September 1995	Comprehensive ground systems test of procedures for launch and early orbit sequences, instrument activation, mission operations, and contingency modes conducted via the GSFC Payload Operations Control Center (POCC) while the spacecraft is located in the high bay at Martin Marietta. Part 2 test is similar in scope to POCC V +V Test (Part 1) but occurs with the spacecraft close to full flight configuration after completion of final environmental tests.
Ship Polar spacecraft to Pad - October 1995	Fully integrated and tested Polar spacecraft shipped to Vandenburg Air Force Base (VAFB) for integration with Delta 11 launch vehicle.
Polar launch - December 1995	Development phase complete. Initial spacecraft checkout followed by initiation of mission operations phase.

ACCOMPLISHMENTS AND PLANS

Since April 1994. the Wind Spacecraft experienced an almost flawless integration and test process. The spacecraft was delivered to the launch site at Kennedy Space Center (KSC) ahead of schedule and was processed and launched successfully on November 1. 1994. A 30 day report following the launch reflects a spacecraft activation and instrument sequence of events with few or no anomalies. Initial Wind operations have provided excellent science data return, with good indications of nominal performance throughout the operational lifetime of the spacecraft.

Following the successful launch of Wind, final integration and test work on Polar work was resumed in December 1994. A new baseline schedule reflects a Polar launch readiness date (LRD) of December 9, 1995. A recent Program Management Council review of the new Polar schedule and remaining funding has certified the schedule and the remaining funds as adequate to complete the program. FY 1995 funds will support extensive system-level testing of the integrated spacecraft. FY 1996 funds support final integration. test and launch operations at Vandenburg Air Force Base (VAFB) by December 1995.

BASIS OF FY 1996 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Collaborative solar terrestrial research..	32,800	23.200	3,800
Tethered satellite system	2,400	3,800	5,700
Shuttle/international payloads	24.300	26,900	23.600
To	59,500	53,900	33.100

PROGRAM GOALS

Physics and Astronomy Payload and Instrument Development supports a number of instruments and payloads to be used on international satellites or on Spacelab missions. International collaborative programs offer opportunities to leverage U.S. investments. obtaining scientific data at a relatively low cost. Spacelab missions utilize the unique capabilities of the Shuttle to perform scientific experiments that do not require the extended operations provided by free-flying spacecraft. The Payload and Instrument Development program supports investigations in all space physics and astrophysics disciplines.

STRATEGY FOR ACHIEVING GOALS

The Collaborative Solar Terrestrial Research (COSTR) program. in conjunction with NASA's development of the GGS spacecraft, represents the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program. Whereas GGS supports development of U.S. spacecraft. COSTR provides U.S. instruments for flight aboard foreign spacecraft. These Include the Solar and Heliospheric Observatory (SOHO), four Cluster spacecraft provided by the European Space Agency (ESA), and the Geotail mission developed by Japan. Geotail was successfully launched in July 1992 and its operation is nominal. The European SOHO and Cluster missions are scheduled for launch in late 1995. The ISTP ensemble of missions will provide overlapping and simultaneous data in FY 1996 aimed at deriving the physics of the behavior of the solar terrestrial system.

The Tether Satellite System (TSS) program is an international cooperative project with the Italian government. A U.S.-developed tether deployment mechanism carried aboard the Shuttle will deploy the Italian satellite (including U.S. Instruments) into the upper atmosphere to perform space plasma experiments while also investigating the dynamic forces acting upon a tethered satellite. The mission originally was flown aboard the Shuttle in July 1992, although a technical malfunction in the deployer resulted in failure to fully accomplish the mission objectives. A reflight of the TSS is therefore planned for the spring of 1996.

Payloads funding also supports development of several instruments designed for flight on the Space Shuttle, including the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS) and Interstellar Medium Absorption Profile

Spectrograph (IMAPS), to be flown on the German-U.S. Shuttle Pallet Satellite (SPAS); Astro-2 (1995) a reflight of the ultraviolet portion of the Astro-1 (1990) mission: and the Infrared Telescope in Space (IRTS, 1995). a joint U.S.-Japanese mission which will be launched on an expendable launch vehicle and recovered by the Shuttle. The ORFEUS/IMAPS, which flew aboard the Shuttle in the summer of 1993 and will be reflown on a future Shuttle mission, explores the character of extreme and far ultraviolet sources, studies the composition and distribution of matter in the neighborhood of the sun, and performs direct observations of the interstellar medium. Astro-2 will perform far ultraviolet spectroscopy, broad-band ultraviolet imaging and ultraviolet polarization studies of galactic and stellar phenomena. The IRTS mission will survey the *sky* for cool galactic and intergalactic phenomena across a broad range of the infrared spectrum.

The program also supports a number of ongoing international and U.S. development projects. These include Astro-E, a Japanese x-ray mission: the High Energy Transient Experiment (HETE. 1995). a small satellite for study of gamma-ray burst phenomena in multiple wavelengths: ground-based support for Japan's Very Long Baseline Interferometry Space Observatory Program (VSOP, 1996) and Russia's RADIOASTRON (1997) program; the Stellar X-ray Polarimeter (SXRP) and Monitoring Experiment (MOXE) instruments to be flown on Russia's Spectrum-X-Gamma (SXG, 1995) mission; U.S. cooperation on the Infrared Space Observatory (ISO. 1995). a European successor to the U.S.-developed Infrared Astronomical Satellite (IRAS, 1983): and portions of two instruments to be flown on Europe's X-ray Mirror Mission (XMM, 1998).

In the FY 1994 appropriation. Congress directed NASA to pursue flight of a GSFC-developed X-ray spectrometer on the Japanese Astro-E mission. NASA will contribute improved foil mirrors and an x-ray calorimeter derived from the spectrometer previously planned for the canceled *AXAF-S* mission. This new device will measure the energy of an incoming X-ray photon by precisely measuring the increase in temperature of the detector as the photon is absorbed. It will provide high quantum efficiency over a large instantaneous bandpass, from 0.3 to 10 keV, at an unprecedented energy resolution of approximately 12 eV. The 32 element calorimeter array will cover approximately 1 arc minute, thus providing approximately 2 arc second resolution. This capability will permit an unprecedented sensitivity study of a wide range of astrophysical sources. answer many outstanding questions in astrophysics, and likely pose many new ones.

HETE is a collaborative program with France and Japan that is managed by the Massachusetts Institute of Technology. As part of its innovative management activities, the university team has obtained an inexpensive satellite from industry, reduced management overhead, relied exclusively on mature technologies. and used contributions from international partners. This mission is to provide information about the precise location of gamma-ray bursters and spectral analysis of these and other high energy transient phenomena.

The Space Very Long Baseline Interferometry (SVLBI) program is composed of the Japanese VSOP and Russian Radioastron missions. These two international missions will provide the highest resolution images of radio sources ever obtained. NASA is participating on the science advisory groups and providing ground processing hardware, tracking support, and the construction of four ground science stations to support both missions. With its extremely long baseline, VSOP and Radioastron will explore very small radio sources with high angular resolution. thereby achieving higher resolution of active galactic nuclei and compact radio sources that can be achieved on the ground. VSOP and Radioastron each has a design life of 3 years.

The U.S.-provided MOXE and SXRP instruments on the Russian SXG mission will complement other instruments on the spacecraft. The Russian SXG mission consists of an x-ray telescope with a complement of focal plane detectors and several auxiliary instruments. The U.S. is providing the SXRP and MOXE instruments to be flown on the SXG and a data archiving system. The SXRP will provide low resolution polarization data across the x-ray spectrum. The MOXE will provide all sky monitoring of transient x-ray events. SXG has a design life of 3 years.

The ESA XMM satellite will have highly sensitive instruments providing broad-band study of the x-ray spectrum. This mission will combine telescopes with grazing incidence mirrors and a focal length greater than 7.5 meters with three imaging array instruments and two Reflection Grating Spectrometers (RGS). The U.S. is providing components to the Optical Monitor (OM) and RGS instruments. The XMM has a lifetime goal of 10 years.

MEASURES OF ERFORMANCE

SOHO L-1/Cluster L-2 Readiness Review - July 1994	Provided an independent assessment of progress toward, and readiness for, mission operations.
SOHO XDL detector deliveries Complete - October 1994	Successfully completed development of replacement detectors for two major SOHO instruments due to failure of baseline detector design in testing.
Astro-2 launch - March 1995	Complete development phase: conduct operations aboard Shuttle mission STS 67.
SOHO launch - October 1995	Spacecraft/instrument integration and test completed: launch aboard Atlas IIAS; initiate mission operations.
HETE launch - November 1995	Spacecraft/instrument integration and test completed: launch aboard Pegasus: initiate mission operations.
Cluster launch - November 1995	Spacecraft/instrument integration and test completed: launch aboard Ariane V initiate mission operations.
TSS launch - February 1996	Refurbishment/integration/test activities completed; conduct operations aboard Shuttle mission STS 75.
VSOP launch - September 1996	Instrument/spacecraft integration and test completed: Japanese launch.

ACCOMPLISHMENTS AND PLANS

In 1994, significant progress has been made towards completion of the development of the COSTR program. All flight model and protoflight model instruments were delivered to the ESA and Japan for integration and test with the SOHO and Cluster spacecraft.

Critical design and fabrication of the new Cross Delay-line (XDL) detectors for SOHO instruments. the German-built Ultraviolet Coronagraph Spectrometer (UVCS) and Solar Ultraviolet Measurement of Emitted Radiation (SUMER) instruments, was completed in October. Failure of the original detectors to survive qualification tests required development of new detectors in only about one year's time --- a significant accomplishment. Additional refurbishment and rework of SOHO and Cluster instruments will be completed in FY 1995 in Europe and Japan in support of planned launches in late 1995.

Refurbishment of the TSS satellite and instrument payload will continue throughout FY 1995 in support of the planned Shuttle mission in February 1996.

In support of Congressional direction, residual FY 1994 *AXAF* funds were applied towards definition of U.S. participation in the Japanese Astro-E mission. The scope of U.S. involvement on the Astro-E mission has recently been very well defined. NASA has reached an understanding with the Japanese as to the extent of our participation: this understanding is expected to be formalized by an international agreement in the very near future. Current plans are for the U.S. to develop selected hardware for an X-Ray Spectrometer (XRS) similar to the instrument previously planned to fly aboard the *AXAF-S* mission. Residual FY 1994 funds from *AXAF* are sufficient to support definition activities throughout FY 1995. Phase B activities for Astro-E will be completed in FY 1995: full-scale development activities will begin in FY 1996 in support of a planned launch in late 1999.

Final integration and test activities are nearing completion for the HETE spacecraft which will launch in mid-late 1995. The SXG instruments, SXRP and MOXE, will be shipped to Russia in support of a 1995 launch. The SVLBI program began compatibility testing of Japanese VSOP hardware with U.S. tracking stations in the fall 1994. First Announcement of Opportunity (AO) for international competition of observing time is expected to be released in the spring 1995, with initial VSOP operations scheduled to begin in September 1996. XMM Phase B studies started in October 1994. Structural thermal models of the instruments are to be shipped by the fall of 1995. Engineering qualification models of the instruments are to be shipped by the summer of 1996 in support of a launch in 1998.

BASIS OF FY 1996 FUNDING REQUIREMENT

EXPLORER PROGRAM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
X-ray timing explorer	36,500	32.600	--
Advanced composition explorer	33,200	39,600	36,000
Small explorers	39.400	33,100	37,900
Explorer planning.	14.200	15,100	55,300
Total	123,300	120.400	129,200

- Total Cost information is provided in the Special Issues section

PROGRAM GOALS

The goal of the Explorer program is to provide frequent, low-cost access to space for Physics and Astronomy investigations which can be accommodated with small to mid-sized spacecraft. The program supports investigations in all space physics and astrophysics disciplines. Investigations selected for Explorer projects are usually of a survey nature. or have specific objectives not requiring the capabilities of a major observatory. The Explorer program continues to seek reductions in the cost of developing spacecraft. in order to provide more frequent launch opportunities for space science missions.

STRATEGY FOR ACHIEVING GOALS

Explorer mission development is managed within an essentially level funding profile. New mission starts are therefore subject to availability of sufficient funding in order to stay within the total program budget. The X-Ray Timing Explorer (XTE) and the Advanced Composition Explorer (ACE) require a Delta launch vehicle. Small Explorers (SMEX) include the Fast Auroral Snapshot (FAST). the Submillimeter Wave Astronomy Satellite (SWAS). the Transition Region and Coronal Explorer (TRACE) and the Wide-field Infrared Explorer (WIRE). These missions will launch aboard a Pegasus launch vehicle. To facilitate more frequent nights. the new Medium-class Explorer (MIDEX) program will be initiated with the anticipated new start of the Far Ultraviolet Spectroscopy Explorer (FUSE) in FY 1996. MIDEX missions will be larger than SMEXs, but smaller and less expensive than Delta class missions and will be launched aboard a new Med-Lite class launch vehicle.

The XTE will use three instruments to conduct timing studies of x-ray sources. A comprehensive record of the source of x-rays with varying intensity over time, characterization of those attributes, and study of compact x-ray emitting objects such as binary stellar masses will be performed by XTE. The XTE spacecraft and one of its instruments are being developed in-house at GSFC,

with two instruments provided by the Massachusetts Institute of Technology and the University of California - San Diego. The XTE was initiated in FY 1990 and is on schedule for launch in August 1995.

The ACE is a space physics mission which will use nine instruments to study the composition of the solar corona, interplanetary and interstellar media, and galactic matter across a wide range of plasma phenomena. The instruments include six high-resolution spectrometers, designed to improve the collecting power of previous systems, to study the mass and charge of plasma phenomena. Three other instruments will provide measures of the lower energy phenomena related to the solar wind. Spacecraft development is provided by the Johns Hopldns University Applied Physics Laboratory, with project management by GSFC. Foreign participation includes the University of Bern and the Max Planck Institute, who provide instrument components and a flight data system shared by three instruments. respectively. ACE development was initiated in November 1993: it is scheduled for launch no later than December 1997.

The FAST will provide high resolution data on the Earth's aurora and how electrical and magnetic forces control them. The flow of electrons, protons, and other ions will be studies with greater sensitivity and spatial discrimination and faster sampling than ever before, using five small university-provided instruments. The FAST data will be integrated with the results of other Earth observing satellites and ground observations. The FAST is managed as a GSFC inhouse project. Major participants include UC-Berkeley, the Lockheed Palo Alto Research Laboratory. the University of New Hampshire, and UC-Los Angeles. FAST development began in FY 1991. The launch of FAST was delayed from September 1994 to August of 1995 due to failure of a Pegasus launch vehicle.

The SWAS will provide discrete spectral data for study of the water, molecular oxygen, neutral carbon. and carbon monoxide in dense interstellar clouds, the presence of which is related to the formation of stars. The SWAS is managed as a GSFC inhouse project. Major participants also include the Smithsonian Astrophysical Observatory, the Millitech Corporation. Ball Aerospace, and the University of Cologne, which provides a spectrometer, The SWAS development started in FY 1991. and is scheduled for launch in July of 1995.

The TRACE is a solar science mission that will explore the connections between fine-scale magnetic fields and their associated plasma structures. Observations of solar-surface magnetic fields will be combined with observations showing their effects in the photosphere, chromosphere. transition region and corona. The TRACE is managed as a GSFC inhouse project. Major participants include the Lockheed Palo Alto Research Laboratory and the Harvard-Smithsonian Center for Astrophysics. The TRACE development began in October 1994 and is scheduled for launch in late 1997.

The WIRE will detect starburst galaxies at a redshift of .5, ultraluminous galaxies at a redshift of 2, and luminous protogalaxies to a redshift of 5. WIRE is managed as a GSFC inhouse project. Major participants include Utah State University, Ball Aerospace, Cornel1 University, CalTech, and the Jet Propulsion Laboratory. The WIRE development was also initiated in October 1994. and is scheduled for launch in late 1998.

The mid-sized Far Ultraviolet Spectroscopic Explorer (FUSE, 2000) mission is currently being restructured, with the goal of reducing costs and accelerating the launch schedule. If approved, FUSE will conduct high resolution spectroscopy in the far

ultraviolet region. Major participants will include the Johns Hopkins University Applied Physics Laboratory, the University of Colorado, and UC-Berkeley. Canada will provide telescope baffles and fine error sensor assemblies. GSFC will provide management oversight of this Principal Investigator-managed mission. NASA will soon be releasing an Announcement of Opportunity for participation in two future missions of the new MIDEX class. MIDEX missions are conceived of as costing under $70 million, expressed in constant FY 1994 dollars. NASA plans to launch the first two MIDEX missions in 1999 and 2000. respectively.

MEASURES OF PERFORMANCE

XTE:	
Begin environmental tests - October 1994	Following completion of integration. the spacecraft entered its series of electrical, magnetic, vibration, thermal/vacuum, and balance tests.
Ship to KSC - June 1995	Spacecraft system level testing successfully completed. Move to pad for integration with Delta 11 launch vehicle.
Launch - August 1995	Development phase completed. Initial spacecraft checkout followed by start of mission operations.
ACE:	
Preliminary Design Review (PDR) - November 1993	Review confirmed overall system design is of sufficient maturity, meets all critical technical and performance requirements, established the compatibility of all major hardware interfaces and represents an acceptable level of technical, cost and schedule risk to the program. Successful completion marks beginning of detailed design phase.
Critical Design Review (CDR) - September 1994	Assess validity and maturity of observatory design as a functionally integrated system in terms of subsystem compatibility. interface requirements and ability to meet all established performance criteria within acceptable levels of technical, cost and schedule risk. Successfully completed: integration/test phase initiated.
Initiate ACE spacecraft subsystem I&T - September 1995	Assembly of the spacecraft begins, as subsystems are delivered.
Begin environmental tests - November 1996	Following completion of integration. the spacecraft enters its series of electrical. magnetic. vibration, thermal/vacuum, and balance tests.
Ship to KSC - July 1997	Spacecraft system level testing successfully complete. Move to KSC for integration with Delta 11 launch vehicle.

Launch - August 1997	Development phase completed. Initial spacecraft checkout followed by start of mission operations.
SWAS:	
Critical Design Review (CDR) - November 1993	Assess validity and maturity of observatory design as a functionally integrated system in terms of subsystem compatibility. interface requirements and ability to meet all established performance criteria within acceptable technical. cost and schedule risk. Successful completion marked beginning of integration/test phase.
Begin environmental tests - February 1995	Following completion of integration, the spacecraft entered its series of electrical, magnetic, vibration, thermal/vacuum, and balance tests.
Begin launch operations - June 1995	Spacecraft system level testing successfully completed. Ship to Vandenburg Air Force Base for integration with Pegasus launch vehicle.
Launch - July 1995	Development phase completed. Spacecraft checkout followed by start of mission operations.
FAST:	
Begin environmental tests - March 1994	Following completion of integration, the spacecraft entered its series of electrical, magnetic. vibration, thermal/vacuum, and balance tests
Begin launch operations - June 1995	Spacecraft system level testing successfully completed. Ship to Vandenburg Air
Launch - August 1995	Development phase completed. Spacecraft checkout followed by start of mission operations.

ISHMENTS AND PLANS

Progress to date on XTE has been very good. It appears that XTE will achieve the aggressive goals set for the program over 3 years ago, by launching on schedule and under budget. Environmental testing is currently underway, with vibration and acoustic testing beginning in January, and will continue through mid-1995. Launch remains on schedule for August 1995.

By the end of FY 1995. CDRs for all of the ACE instruments will have been completed. Spacecraft subsystem development is scheduled to advance sufficiently to allow the start of integration and test this summer. Instruments are scheduled for shipment to the spacecraft during the latter part of FY 1996 in support of an August 1997 launch.

The FAST and the SWAS are both scheduled for launch in mid-1995. The FAST was previously scheduled for launch in late FY 1994, but is currently on standby due to the recent failure of the Pegasus launch vehicle. The SWAS spacecraft and instrument

hardware fabrication and testing activities are nearing completion, and preparations are underway to initiate system-level environmental testing in support of a launch in mid-late 1995. Two new SMEX missions, TRACE and WIRE were selected in 1994 as new developments beginning in FY 1995. In keeping with the SMEX philosophy of low-cost missions with short development schedules, both TRACE and WIRE will complete design activities in FY 1995, and development of components will be completed in FY 1996. TRACE is scheduled for launch in late 1997, and WIRE launch is scheduled for late 1998.

Funding from the Explorers planning line will support the FUSE mission until the schedule and budget for the restructured mission is approved. Also supported will be advanced planning and studies for the future MIDEX missions. NASA also plans to fund a technology development program within the Explorer program. with the goal of reducing the weight and cost of future small spacecraft. The size and scope of this technology development effort are currently under review.

BASIS OF FY 1996 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
HST operations and servicing	215,200	236,700	182.700
HST data analysis	38,500	42.700	43.500
AXAF mission operations and data analysis	11,600	18.900	40.400
Astrophysics mission operations and data analysis	84.500	84,700	79,600
Space physics mission operations and data analysis	55.400	49.400	82.400
To	405.200	432.400	428.600

PROGRAM GOALS

The Mission Operations and Data Analysis (MO&DA) program is fundamental to achievement of the goals of the Office of Space Science (OSS) program. Funding supports satellite operations during the performance of the core missions of astrophysics and space physics spacecraft, extended operations of selected spacecraft, and for ongoing analysis of data after the usable life of spacecraft has expired. Funding also supports pre-flight preparations for satellite operations and data analysis activities, and long-term data archiving and data base services. Also supported are preparations for future servicing of the Hubble Space Telescope (HST), including development of advanced science instruments. Furthermore. the MO&DA program attempts to dramatically lower operations costs while preserving, to the greatest extent possible, science output. To do so, it will accept prudent risk, explore new conceptual approaches, streamline management, and make other changes to enhance efficiency and effectiveness.

STRATEGY FOR ACHIEVING GOALS

Hubble Space Telescope (HST) science operations are carried out through an independent HST Science Institute, which operates under a long-term contract with NASA. Satellite operations, including telemetry, flight operations. and initial science data transcription. are performed on-site at Goddard Space Flight Center under separate contract. While NASA retains operational responsibility for the observatory, the Science Institute plans, manages, and schedules the scientific operations. In a single year of operations, the activities of over 500 scientists are supported under the HST program, and over 15,000 observations recorded. In order to extend its operational life and provide a basis for future enhancements of its scientific capabilities, HST is designed to be serviceable. This requires on-orbit maintenance and changeout of spacecraft subsystems and scientific instruments about every three years. Ongoing modification and upkeep of system ground operations are also performed.

Re-launch operations funding for the Advanced X-ray Astrophysics Facility (AXAF) program supports the development of a ground control system, *AXAF* Science Center (ASC) and preparation for flight system operation. A common ground system located at the Marshall Space Flight Center (MSFC) will be used to serve the combined requirements for the Space Shuttle, Spacelab, and AXAF flight operations. The ASC, developed by the Massachusetts Institute of Technology (MIT), supports x-ray calibration of the flight mirror assembly and instruments using a precursor of the AXAF data system during the pre-launch phase of the program and will ultimately serve a key role in the management of science operations.

Currently, five operational missions in astrophysics and eight operational missions in space physics are supported. Astrophysics missions include the Compton Gamma-Ray Observatory (CGRO, 1991), the Extreme Ultraviolet Explorer (EUVE, 1992). the International Ultraviolet Explorer (IUE, 1978). and U.S. participation in the international Roentgen Satellite (ROSAT, 1990) and Japanese Astro-D/ASCA (1993). Space physics missions include Wind (1994). Geotail (1992). the Japanese cooperative satellite Yohkoh (1991). Ulysses (1990). Voyager 1 and 2 (1977). Pioneer 10 and 11 (1972. 1973). SAMPEX (1992). and the Interplanetary Monitoring Platform (IMP-8, 1973).

The CGRO measures gamma-rays, providing unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars, supernova, and the nature of the mysterious cosmic gamma-ray bursts. EUVE is studying the *sky* at wavelengths once believed to be completely absorbed by the thin gas between the stars. IUE continues to provide valuable data in ultraviolet wavelengths for U.S. and European scientists. U.S. observers continue to enjoy 50% of the observing time (shared with Germany and the UK) from the highly successful ROSAT X-ray satellite. The Japanese/U.S. Astro-D/ASCA spacecraft is conducting spatially resolved spectroscopic observations of selected cosmic x-ray sources. Wind studies the solar wind input of mass and energy to the Earth. Wind also carries a Russian gamma-ray instrument, the first Russian instrument ever to be flown on a U.S. spacecraft. Geotail, a Japanese spacecraft studying the earth's magnetotail, and the U.S. Wind spacecraft are the first part of the cooperative International Solar Terrestrial Physics (ISTP) program. The Yohkoh spacecraft, a cooperative program with the Japanese, is continuing to gather x-ray and spectroscopic data on solar flares and the corona. Ulysses is currently studying the sun's polar regions, measuring the interplanetary medium and solar wind as a function of heliographic latitude. Voyager 1 and 2 and Pioneer 10 and 11 are continuing to probe the outer heliosphere and look for the heliospheric boundary with interstellar space as they travel beyond the planets. SAMPEX is measuring the composition of solar energetic particles, anomalous cosmic rays, and galactic cosmic rays.

MEASURES OF PERFORMANCE

AXAF:

On-Line System Preliminary Design Review (CDR) - July 1994	Validate design/maturity of hardware and software systems which support primary aspects of AXAF operations, including data acquisition and distribution to *AXAF* Science Center (ASC), spacecraft command/telemetry, etc.
Off-Line System Preliminary Design Review (PDR) - December 1994	Validate design/maturity of software system which is used to process spacecraft command loads generated by mission planners and flight operations team.

On-Line System Critical Design Review (CDR) - March 1995	Major design review for hardware and software systems which support primary aspects of AXAF operations, including data acquisition and distribution to AXAF Science Center (ASC), spacecraft command/telemetry, etc.
Off-Line System Critical Design (CDR) - September 1995	Validate design/maturity of software system which is used to process spacecraft command loads generated by mission planners and flight operations team.
Off-lineRelease 1 -January 1996 On-line Release 1 - February 1996	First major deliveries of ground system hardware and software for integrated systems testing.
HST: 1st Servicing Mission - November 1993	Restore HST to full operational status. Install corrective optics, replace defective solar arrays, replace High Speed Photometer (HSP) with Wide Field/Planetary Camera -- WF/PC-II.
NICMOS & *STIS* Critical Design Reviews (CDRs) - August 1994 - October 1994	Conduct 2-phased review of HST replacement instruments to be installed during second HST servicing mission. August reviews examined hardware! subsystem designs and interfaces (electrical. thermal, etc.) October reviews examined detailed designs for software and operations.
2nd Servicing Mission Critical Design Review (CDR) - July 1995	Detailed review of overall content and procedure for the 1997 second servicing mission.
Cargo Integration Review for the Second Servicing Mission - March 1996	Completes coordination of HST flight hardware and carriers destined for the space shuttle cargo bay with JSC payload integration.
Delivery of NICMOS and STIS to GSFC - August 1996	Instrument development activities completed. Shipped to GSFC to begin final integration and testing.
2nd Servicing Mission - February 1997	Replace Faint Object Spectrometer (FOS) and Goddard High Resolution Spectrometer (GHRS) with *STIS*. add NICMOS instrument, other replacement hardware as required.
ISTP missions: Wind Launch - November 1994 Polar launch - December 1995 SOHO launch - October 1995 Cluster launch - November 1995	Acquire in-situ and remote sensing measurements of Sun-Earth environment from different locations in near-Earth space. Launch dates are important factor in maintaining operations overlap with other ISTP missions.

Explorers:	
SWAS launch - July 1995	Acquire discrete spectral data for study of the chemical composition of dense interstellar clouds, the presence of which is related to the formation of stars.
XTE launch - August 1995	Conduct timing studies of x-ray sources with varying intensity over time. characterization of those attributes, and study of compact x-ray emitting objects such as binary stellar masses.
FAST launch - August 1995	Provide high resolution data on the Earth's aurora and how electrical and magnetic forces control them.
Ulysses:	
1st Solar Polar pass: June-October 1994 2nd Solar Polar pass: June-September 1995	Explore the heliosphere over the full range of solar latitudes (polar regions previously unexplored) and to provide an accurate assessment of the total solar environment.

ACCOMPLISHMENTS AND PLANS

The first Hubble Space Telescope (HST) servicing mission in December 1993was a tremendous success. The mission restored the faint object and crowded field capabilities of the telescope. which had been unavailable due to spherical aberration of the primary mirror. *Also.* jitter induced by thermal effectson the observatory's solar arrays has been corrected by the installation of two modified solar arrays provided by the European Space Agency. Several subsystems, including gyroscopes and a data processing system, were installed so as to restore redundancy and to ensure operations until the next servicing mission occurs. The observatory is now fulfilling the promises NASA made for it, generating an ongoing stream of major scientific discoveries. HST is generating great public interest as measured by several major news and television reports over the past twelve months. HST images are also being distributed to school children nationwide through NASA's national Teacher Resource Laboratory"system. Recently, a set of detectors under development for the HST has attracted a great deal of attention due to technology spin-offs. Early development of these detectors was done within the astrophysics Advanced Technology Development program. These detectors have been adapted for use in mammography. and significantly reduce the radiation exposure to patients. This new mammography technology is breaking into the health care field, and is expected to rapidly become the standard. In addition, the same technology is under assessment by the utilities industry as a means of detecting discharges from leaking electrical power lines. Such an application holds the potential for saving the nation billions of dollars in utility bills by improving transmission efficiency.

Planning for the second HST servicing mission in 1997 is ongoing. Critical Design Reviews (CDRs)for the Space Telescope Imaging Spectrograph *(STIS)*and Near Infrared Camera/Multi-Object Spectrometer (NICMOS)were completed in 1994. Integration and test activities will continue throughout FY 1995 in support of an August 1996 delivery to Goddard for final integration and testing. In an effort to reduce outyear funding requirements, estimated costs for an Advanced Camera for the third servicing mission in 1999 have been reduced by more than a factor of two, with minor impact to science: this has been accomplished

through acceptance of higher technical and programmatic risk, and a reduced development schedule.
Detailed design of the AXAF ground system on-line and off-linesystems were conducted, and will continue throughout FY 1995. Funding in FY 1996 will support the first major deliveries of ground hardware and software for integrated systems testing.

In September 1995, the Ulysses spacecraft passed over the south polar region of the sun providing the first measurements of the solar wind emerging from the solar poles. It found a wind twice as fast and with different composition than in low latitude regions, a lower than expected penetration of cosmic rays from outside the solar system, and a magnetic field with large low frequency waves. The outer heliospheric spacecraft (Pioneersand Voyagers) are finding evidence that the they may encounter the heliospheric shock (region where the Sun's dominance of space terminates) as early as 1998. Geotail is finding that conditions in the Earth's magnetic tail are more complex than expected. The Solar Anomalous Magnetospheric Particle Explorer (SAMPEX) is providing the first detailed measurements of interstellar material that is brought into the Earth's space environment in the form of energetic particles.

In order to accommodate a growing number of operational spacecraft within MO&DA budgets that are significantly lower than previously expected, NASA is continuing to pursue cost savings while minimizing science impact. Cost reduction effortsin many projects are showing results. For missions like CGRO and EUVE. flight operations teams have been reduced from 23 to 19 Full-Time Equivalents (FTEs); further reductions to the 13-14 FTE range will be possible in 96-97 when the mission Operations control centers have been converted from dedicated computers to workstation-based generic systems. The science instrument operations team for EUVE is in the middle of a staffing reduction program to convert from three-shift operation to single-shift operation. On the science analysis side, astrophysics has systematically standardized data formats and modularized data analysis software packages. Because of such savings and innovations, funding requested should be sufficient to support all currently operating missions, as well as all newly launched missions, through FY 1996.

In FY 1995, the remaining components of the International Solar Terrestrial Physics (ISTP) program will be launched (SOHO, Polar, and Cluster) to join Geotail and Wind in orbit. This mission set, along with complementary missions probing the heliosphere (Ulysses, Pioneers 10 and 11, Voyagers 1 and 2), the cooperative Japanese Yohkoh spacecraft, and the small Explorer missions SAMPEX, will provide an unprecedented opportunity to study solar variability and the effects of this variability on the Earth's space environment, and upon the heliosphere at high latitudes and out to distances beyond 60 AU (an AU corresponds to the Earth's distance from the Sun). However, Pioneer 11 operations will probably be terminated during FY 1995 as a result of the decreasing power supply on board the spacecraft.

Other missions to be launched include the X-ray Timing Explorer (XTE 8/95). the Submillimeter Wave Astronomy Satellite (SWAS 7/95), Polar (12/95), the Solar and Heliospheric Observatory (SOHO 10/95), Cluster (11/95), and the Fast Auroral Snapshot (FAST 8/95).

BASIS OF FY 1996 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Space physics supporting research and technology.....	35,700	35.700	35,700
Astrophysics supporting research and technology.....	35,400	39.700	39,700
Space infrared telescope facility definition	---	---	15,000
To.....	71.100	75,400	90,400

PROGRAM GOALS

The goals of the Research and Analysis (R&A) program in Physics and Astronomy are to: (1) optimize the design of future missions through science definition. development of advanced instruments and concepts, and definition of proposed new missions: (2) strengthen the technological base for sensor and instrument development: (3) enhance the value of current space missions by carrying out ground-based observations and laboratory experiments: (4) conduct the basic research necessary to understand astrophysics phenomena and solar-terrestrial relationships and develop theories to explain observed phenomena and predict new ones: and, (5) continue the acquisition, analysis and evaluation of data from laboratories, airborne observatories, balloons, rocket and spacecraft activities. In addition to supporting basic and experimental astrophysics and space physics research for future flight missions, the program also develops and promotes United States scientific and technological expertise.

STRATEGY FOR ACHIEVING GOALS

The R&A program carries out its objectives by providing grants to universities, nonprofit and industrial research institutions. and funds to scientists at NASA Centers and other government agencies. Several hundred grants are awarded each year to the community of scientists. These grants help train future investigators in space science disciplines -- science and engineering graduate and post graduate students who will become the nation's future scientific leaders.

Funding also supports Advanced Technology Development (ATD) activities which develop new mission concepts and ensure that the technology for a mission is mature before development begins in order to minimize cost, schedule, and technical risks. Mission concept and definition studies are also used to identify and define new and usable technologies and optimize their use within an affordable development cost. Increasing emphasis is being made within the Agency to better utilize advanced technologies in future missions.

MEASURES OF PERFORMANCE

Technology development of advanced x- and gamma ray detectors (Ongoing)	Significant progress made in FY 1994. Test program provided improvements in spectral resolution, imaging capability and detector efficiency (sensitivity). Flight tests aboard sounding rockets and balloon planned for FY 1995. Development of solid state gamma-ray detectors which may be operated without cryogenic cooling is a goal for FY 1996.
Technology development of advanced Ultraviolet (U/V) detector systems (Ongoing)	Major new developments in delay-line microchannel plate detector electronics and anode fabrication achieved in FY 1994. Technology used to support replacement of defective detectors on SOHO mission. Completion of 3 year study in planned for FY 1996. Advanced detectors developed here will be flown on future U/V missions such as FUSE and HST Advanced Camera.
Theoretical studies of solar physics (Ongoing)	Advanced generation numerical codes for analysis of solar x-ray data developed FY 1994. These codes will aid in the development of theoretical models for comparison with observed plasma ejections from the Sun, known to be fundamental to solar terrestrial relationships.
Theoretical studies of the Heliosphere (Ongoing)	Studies planned in FY 1995 to predict the location and physical characteristics of the boundary of the heliosphere in anticipation of its encounter by the Pioneer and Voyager spacecraft.
Magnetospheric Physics studies (Ongoing)	Data from the Geotail mission will be integrated with theoretical models in FY 1995 to provide an enhanced understanding of physical and chemical characteristics of the Earth's magnetic field.
SOFIA:	
Wind tunnel testing completed - August 1994	Phase B Studies complete. Technical feasibility of the aft mount telescope configuration confirmed through extensive wind tunnel tests at ARC for the Boeing 747-200 and 747SP aircraft. Both versions determined acceptable.
Non-Advocate Review - February 1995	Conduct preliminary review of program to identify key technical challenges, highlight cost/schedule concerns and identify other program issues for remedial action to assure acceptable level of cost. technical and programmatic risk prior to initiation of program.
Aircraft version selected - March 1995	Final decision on acquisition of Boeing 747-200 or 747SP based on performance, modification requirements, purchase price, availability, operations costs, etc.

Request for Proposal (RFP) draft complete - July 1995	Documentation to support industry proposals for aircraft modification contract ready for release. Release contingent upon new start in FY 1996.
SIRTF:	
Phase A studies completed - September 1996	JPL inhouse studies of alternative mission designs reviewed for relative technical merits (complexity, feasibility, etc) cost and schedule requirements.
Complete Spacecraft Request for Proposal (RFP) - September 1996	Documentation to support industry proposals for spacecraft development contract ready for release. Release contingent upon new start approval in FY 1997.

ACCOMPLISHMENTS AND PLANS

The R&A program continued to provide exciting scientific discoveries in 1994. In space physics, bright blue and red upper atmospheric flashes extending upward as high as 60 miles were captured on film for the first time. Some of these flashes, which last only a few hundredths or thousandths of a second, reach through the ozone layer to the ionosphere. These flashes link weather in Earth's lower atmosphere to events in the upper layers of the atmosphere, through a process that is not yet well understood. In astrophysics. amino acids were discovered around the galactic center. The distant presence of Glycine. one of the building blocks of life, could be an important clue to the distribution of organic matter in the universe. Significant progress has been made in the development and testing of innovative new x- and gamma-ray detectors: improvements were in the important areas of enhanced spectral resolution, finer imaging capability, and detector efficiency (sensitivity). A major development in detector technology was achieved by Dr. Oswald Siegmund. in delay-line microchannel plate detector electronics and anode fabrication. Siegmund's work enabled rapid development of last minute replacement detectors for the SOHO mission.

Also during FY 1994, the space physics program has investigated uses and techniques for tethered spacecraft to directly sample atmospheric regions (mesosphere and lower thermosphere) otherwise inaccessible by orbiting spacecraft. Study of the Earth's inner magnetosphere has received renewed emphasis owing to the recognized importance of electrical coupling between ionospheric and magnetospheric processes, the time evolution of such processes, and the exchanges of particles that take place following large space weather events. Advanced generation numerical codes for analysis of solar x-ray data have been developed: these codes have breakthrough abilities to model the observed plasma ejections from the Sun. known to be fundamental to solar terrestrial relationships.

In the FY 1995 astrophysics program, several flight tests of innovative x- and gamma-ray detectors aboard balloons and sounding rockets will be performed with the prospect of providing critical new information on several topics of very high interest. including the nature of the enigmatic source of matter/antimatter radiation from the direction of the center of our Milky Way Galaxy and the origin of the isotropic, diffuse cosmic x-ray background. Observations are planned of the brightest extreme ultraviolet radiation source, epsilon Cma, and our closest galaxy, the Large Magellanic Cloud (LMC) using newly developed payload instruments such as a high resolution spectrometer. The development of suborbital payloads continues, including post-COBE follow-up investigations on anisotropies in the cosmic microwave background radiation at improved sensitivity and angular resolution - experiments likely to function as pathfinders for a future orbiting mission.

Also during FY 1995, the space physics program is seeking to perform radioactive dating of the cosmic radiation and to predict the nature, location, shape and thickness of the heliosphere's boundary in anticipation of its encounter by the Pioneer and Voyager spacecraft. Energy storage, plasma energization and flow rate, and the morphology of the magnetic field will be studied using new data from the Geotail missions and powerful new computer codes and theory. The program will also provide final reports that define a multi-faceted effortto study the detailed interaction of solar magnetic fields and the associated flow of plasmas that lead to the variability of the Sun.

The astrophysics ATD program will continue to support definition studies for the Stratospheric Observatory for Infrared Astronomy (SOFIA)through FY 1995 in support of an FY 1996 new start. Phase B studies for SOFIA were successfully completed in FY 1994. The technical feasibility of the aft mount telescope configuration was confirmed through extensive wind tunnel tests at ARC for both the Boeing 747-200 and 747SP aircraft.

During FY 1996. the astrophysics program anticipates significant progress in two new promising detector technologies which will greatly enhance our capability to simultaneously image and spectrally resolve cosmic x- and gamma-ray sources with unprecedented resolution and sensitivity. These include the development of solid state gamma-ray detectors which may be operated effectively without the need for cooling to cryogenic temperatures and x-ray sensors with the fine spectral capability of calorimeters, but which may be arrayed in a fashion akin to Charge Coupled Devices (CCDs). In addition, a vigorous laboratory program in ultraviolet astrophysics is planned, including the development of synthetic extreme ultraviolet spectra and the measurement of ultraviolet transition probabilities and atomic oscillator strengths. This program will aid in the interpretation of data from the HST. EUVE, ORFEUS, and Astro-2 missions.

Additional FY 1996 funding is included for mission definition activities related to the Space Infrared Telescope Facility (SIRTF), in anticipation of entering development soon thereafter. SIRTF is the last of the four Great Observatories and has been the highest priority new mission (as ranked by the National Academy of Sciences) in astrophysics for many years. especially because of the breakthroughs in infrared detector technology in the U.S. SIRTF's exquisite sensitivity will complement SOFIA's high spatial and spectral resolution. Through a series of restructuring efforts over the past three years, the anticipated lifecycle costs have been reduced by approximately a factor of five. SIRTF may also include a collaboration with the Japanese to achieve a portion of its science objectives. JPL is responsible for program management.

Also during FY 1996, the space physics program will seek to understand the composition and dynamic physical processes of the solar, interplanetary and galactic regimes which create cosmic rays, and the galaxy and solar system through which they travel: to place limits on the existence of antimatter galaxies and forms of dark matter in the universe: to understand the dominant physical processes that characterize the transition between the Earth's uppermost atmospheres and space and the transfer of energy through this boundary region owing to variations in solar emissions: to optimize high energy observing technologies and research concepts for the study of solar flares from space during the next epoch of maximum solar activity: to refine revolutionary gamma-ray and hard x-ray imaging spectroscopy techniques in order to define small missions for the advanced study of solar flares: and to determine the plasma populations in the Earth's space environment and their Variations over large spatial regimes using novel remote sensing, imaging techniques. Advances in technology and modeling capability will lead to the development of new instrumentation to image otherwise invisible plasma distributions in the Earth's space environment.

BASIS OF FY 1996 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Airborne program			
Kuiper airborne observatory	13,600	13,200	3,400*
Stratospheric observatory for infrared astronomy	--	--	48,700
Balloon program	16,400	16,000	16,000
Sounding rockets	39.500	38.000	38,600
Total	69,500	67,200	106,700

* Assumes $9.7 million offset due to planned termination of Kuiper Airborne Observatory (KAO) operations and initiation of **SOFIA.**

PROGRAM GOALS

The principal goal of the Suborbital program is to provide frequent, low-cost flight opportunities for space science payloads to conduct research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. The program also serves as a technology testbed for instruments which may ultimately fly aboard orbital spacecraft, thus reducing cost and technical risks associated with the development of future space science missions.

STRA FOR ACHIEVING L

The Suborbital program provides the science community with a variety of options for the acquisition of in-situ or remote sensing data. Aircraft, balloons and sounding rockets provide access to the upper limits of the Earth's atmosphere. The Spartan program provides access to space by supporting deployable payloads for flight aboard the Shuttle. Activities are conducted on both a national and international cooperative basis.

Astronomical research with instrumented jet aircraft has been an integral part of the NASA Physics and Astronomy program since 1965. For relatively low cost, NASA has been able to provide to the science community very quick, global response to astronomical "targets of opportunity." The Airborne program has provided support for the Kuiper Airborne Observatory (KAO) since 1974. This facility has consisted of a specially modified C-141 aircraft platform that carries a 0.91 m infrared telescope to altitudes above 41,000 ft for 5+ hour scientific research flights. Operations at these altitudes enable routine access to most of the infrared spectrum from one micrometer to a few millimeters. With the exception of a few very narrow spectral "windows", this region is not accessible from the ground due to absorption by the water vapor at lower altitudes in the Earth's atmosphere. The program is managed by the Ames Research Center *(ARC)* with all science payloads selected via an annual peer review held at ARC.

The Stratospheric Observatory For Infrared Astronomy (SOFIA) is a new airborne observatory designed to replace the aging KAO. and consists of a 2.5 m telescope provided by the German Space Agency (DARA) integrated into a used Boeing 747 aircraft. With spatial resolution and sensitivity far superior to the KAO, SOFIA will facilitate significant advances in the study of a wide variety of astronomical objects, including regions of star and planet formation in the Milky Way, activity in the nucleus of the Milky Way, and planets, moons, asteroids and comets in our Solar System. The program will build upon a very successful program of flying teachers on the KAO by reaching out to K-12 teachers as well as science museums and planetaria around the country. Initial development of SOFIA is planned for FY 1996, with initial operations by the end of 2000. KAO is scheduled to terminate operations beginning in FY 1996 If initial development of SOFIA is approved. The savings from cessation of KAO operations are an integral element of the funding plan for SOFIA.

The Balloon program provides a cost-effective means to test flight instrumentation in the space radiation environment and to make observations at altitudes that are above most of the water vapor in the atmosphere. In many instances it is necessary to fly primary scientific experiments on balloons, because of size, weight, or cost considerations or lack of other opportunities. Balloon experimentation is particularly useful when studying infrared, gamma-ray, and cosmic-ray astronomy. In addition to the level-of-effort science observations program, the program has successfully developed balloons capable of lifting payloads greater than 5000 pounds. In addition, the balloon program is now capable of conducting a limited number of missions lasting nine to fourteen days: successful long-duration flights have been conducted in the Antarctic. and more are planned. The Balloon program is managed by the NASA/GSFC Wallops Flight Facility (WFF). Flight operations are conducted by the National Scientific Balloon Facility (NSBF), a govemment-owned, contractor-operated facility in Palestine. Texas.

Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics. and composition of the magnetosphere and near space: the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurora and the coupling of energy into the atmosphere: and the nature, characteristics, and spectra of radiation of the sun, stars and other celestial objects. In addition. the sounding rocket program provides several science disciplines with the means for flight testing of instruments and experiments being developed for future flight missions. The program also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft. The program is managed by GSFC/WFF, and launch operations are conducted from facilities in White Sands, New Mexico and Poker Flats, Alaska.

The Spartan program provides small, reusable spacecraft which can be flown aboard the Shuttle. These units can be adapted to support a variety of science payloads and deployed from the Shuttle cargo bay to conduct experiments for a short time (i.e. several hours or days). Payloads are later retrieved, reinstalled into the cargo bay and returned to Earth. The science payload is returned to the mission scientists for data retrieval and possible refurbishment for a future flight opportunity. The Spartan carrier is also refurbished and modified as needed to accommodate the next science payload.

MEASURES OF PERFORMANCE

KAO operations:	
FY **1994**	**74** flights achieved. including **7** flights to observe comet Shoemaker-Levy **9** collision with Jupiter in July. Flights provided educational flight opportunity for **20** teachers.
FY 1995	**40** flights planned. Reduced flight rate due to aircraft to be taken out of service from September through March for major maintenance.
FY 1996	Anticipated termination of KAO operations beginning in FY **1996.** Contingent upon FY **1996** new **start** approval for **SOFIA.**
Balloon Program:	
FY **1994**	**22** flights achieved, including **2** Antarctica flights designed to detect the origin of cosmic rays from galactic sources.
FY 1995	**20-25** flights expected. Antarctica campaign **(2** flights) will serve **as** engineering test flights for new instruments designed to increase statistical data on origin. energy and composition of cosmic rays derived from **1994** campaign. Australian campaign **(5** flights) will measure gamma ray emissions from the Galactic center and study selected celestial objects that can only be observed in the Southern Hemisphere.
FY 1996	**20-25** flights planned, including **2** long-duration missions over Arctic regions which will re-fly new instruments flown over Antarctica in FY **1995** campaign.
Sounding Rocketg:	
FY **1994**	**33** flights achieved, including **1** flight to obtain ultraviolet imagery of comet Shoemaker/Levy impact with Jupiter. Complemented observations from Galileo, HST, **KAO** and ground observatories.
FY 1995	**30-35** flights expected. Poker Flats campaign **(9** flights) will study a variety of auroral acceleration processes and their effects on the **Earth's** upper atmosphere.
FY 1996	Approximately **35** flights planned. International Australia campaign **(5** flights) will conduct astrophysics observations unachievable from the northern hemisphere.

Spartan:	
Spartan 201 September 1994 - July 1995	Space Physics missions observe and measure the solar source of the solar wind. Conduct investigations of solar wind as correlative data measurements to Ulysses
Spartan 204 - February 1995	Perform Shuttle glow experiments and uses the Far Ultraviolet Imaging Spectrograph to view diffuse sources of light from distant galaxies.
Spartan 206 - November 1995	Payload developed by Office of Space Access and Technology (OSAT) which carries instruments to measure noble gases, contamination and erosion potential of space environment.
Spartan 207 - April 1996	Inflatable Antenna Experiment developed by Office of Space Access and Technology (OSAT).
SOFIA:	
Initiate aircraft procurement - January 1996	Acquisition of a suitable Boeing 747 aircraft is a critical path item as it is the principal driver of the aircraft modification design.
Initiate SOFIA aircraft modifications - June 1996	This activity is the largest single procurement in the SOFIA program. Its schedule is driven by the early acquisition of the aircraft and a streamlined procurement activity.
In-house Systems Preliminary Design Review (PDR) - September 1996	Initial detailed review of key program elements of program which will be designed at the ARC. These include the aircraft's shear layer control system, cavity door, consoles and electronics systems.

ACCOMPLISHMENTS AND ANS

In 1994, the KAO flew 74 research flights that involved 32 Principal Investigators and logged more than 560 hours of observation time. In addition, 20 teachers from grades K-12 were given the opportunity to fly aboard the KAO. In FY 1995, the KAO is expected to fly more than 40 research flights. This included a highly successful deployment to Australia for observations of the comet Shoemaker-Levy 9 as it impacted the planet Jupiter in July. KAO is scheduled to terminate operations beginning in FY 1996 if initial development of SOFIA is approved. The savings from cessation of KAO operations are an integral element of the funding plan for SOFIA. FY 1996 funds support the purchase of a used Boeing 747 aircraft, aircraft refurbishment, and initial design activities by a prime contractor selected to modify the aircraft into a flying observatory. In addition, a Memorandum Of Understanding (MOU) with DARA would also be signed. Initial operations for SOFIA would begin in late 2000.

In FY 1994, 33 sounding rockets and 22 balloons were flown. Of particular interest were the observations of comet Shoemaker-Levy 9 impact with Jupiter in July, and the highly successful sounding rocket campaign in Brazil in which thirteen rockets were flown to study the ionosphere at the Earth's magnetic equator. Recent developments in long-duration ballooning capabilities are

now available to accommodate 1-2 ton payloads for periods of up to 2 weeks. This capability provides an alternative to Spacelab missions for some investigators, and are now being used in polar campaigns to fly cosmic ray experiments where the event rate is especially low. Funding in FY 1995-FY 1996 will support an anticipated 20-25 balloon flights and 30-35 sounding rocket flights.

Spartan 201 consists of a 17-inch diameter solar telescope with an ultraviolet coronagraph and a white light coronagraph to observe and measure the solar source of the solar wind. Spartan 201 had highly successful flights in 1993 and 1994, and another reflight is planned for 1995 to provide correlative data for the Ulysses mission during its passage over the northern solar pole. Spartan missions are also planned for FY 1995 and FY 1996 which support an astrophysics payload and two experiments developed by the Office of Space Access and Technology (OSAT).

BASIS OF FY 1996 FUNDING REQUIREMENT

ORMATI(SYSTEMS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Information systems..	26,500	26,100	25,900

PROGRAM GOALS

The Information Systems program is fundamental to the attainment of the overall technical and scientific goals of the Office of Space Science (OSS). The program provides state-of-the-art data management, networking, and computing capabilities which support research activities in all disciplines and provide the means for optimal exploitation of all science data acquired.

STRATEGY FOR ACHIEVING GOALS

The Information Systems program will provide access to high performance networking, computing and data management, and an interactive analysis environment with efficient access to data, mathematical processes tools, and advanced visualization techniques. Multiple science disciplines will be supported by the projects funded under this program.

NASA's National Space Science Data Center (NSSDC) at the Goddard Space Flight Center archives and distributes data acquired in space flight programs. A master directory service for distribution of science data to a wide range of users is also maintained. In addition, support is provided for development of search techniques to access data from multiple databases and to assimilate data from multiple data sets into single applications.

The NASA Science Internet (NSI), managed by the Ames Research Center, is a computer networking service used to provide access to flight program databases, data processing systems, and to other applications for scientific collaboration available through the Internet. Researchers and organizations participating in the NASA-funded flight programs and in joint international missions are supported through this network service. This service is closely coordinated with other U.S. computer networking facilities.

Funds provided for information system research and technology are used to improve science data management capabilities, to improve scientist's productivity by developing enhanced analysis and visualization techniques and to facilitate the transfer of new information technologies into the private sector. Principal Investigators at universities and research centers throughout the U.S. and Canada are selected through peer-reviewed NASA Research Announcements to participate in this portion of the program.

ASURES OF PERF

Shuttle Radar Imaging Mission - April 1994	Visualization and animation techniques developed for Magellan radar data adapted to acquire real-time, multispectral data. fused into a single image.
Establish Mars Global Database - July 1994	Interactive science data visualization enabled by higher performance parallel computing adapted for use with Mars global map. Allows Mars "flyover" guided by workstation mouse over Martian terrain.
Comet Shoemaker-Levy9 impacts with Jupiter - July 1994	Worldwide distributed science event, with broad participation by general public. Over 2.5 million accesses to images made available on World Wide Web servers.
Establish industry partnerships - October 1994	Cooperative agreement with two companies to transfer high performance computing and visualization capabilities for broadened commercial applications.
Internet connections to South America and Argentina - FY 1995	Strengthened collaboration with joint projects and science colleagues.
Master Directory and other Services fully operational at NSSDC - FY 1995	One-stop shopping available to both science community and general public for all science data assets archived in widely distributed locations. Also linked to World Wide Web Home Page browse capability.
Global mosaics of Jupiter and Mars - April 1996	Data from various sources adapted to produce global images of Jupiter and Mars. Data will also be incorporated into comprehensive database which allows user to interactively peruse the solar system.
Develop enhanced mission simulation techniques - FY 1996	Develop integrated capability to test and evaluate full suite of computing and related technologies for data compression, autonomous spacecraft operations, flight/ground system trade-offs, etc.

ACCOMPLISHMENTS AND PLANS

Advanced networking has enhanced the research environment, and also has accelerated the access and utilization of the science data by the general public, making them more broadly available to traditionally unserved communities. For example, in July 1994, the week in which the Comet Shoemaker-Levy 9 collided with Jupiter, the NSSDC's World Wide Web system experienced nearly 500,000 accesses. The World Wide Web systems at the HST Science Institute and Jet Propulsion Laboratory experienced 500,000

and 1,500,000 accesses, respectively. In FY 1994. the NSSDC On-Line Data and Information Services (NODIS) system was accessed almost 40.000 times by the user community. The NSSDC Data Archive and Distribution Services (NDADS) system received approximately 20,000 requests for data during the same timeframe.

Based on historical trends, it is anticipated that demands for NSSDC and NSI services in FY 1995 and FY 1996 will be even greater. However, the combination of increasing user demands and the constrained budget environment will require tradeoffs between investments in advanced technologies, such as visualization tools and technology testbeds, and support of current NSSDC and NSI services.

BASIS OF FY 1996 FUNDING REQUIREMENT

LAUNCH SERVICES

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Ultra-lite	--	15,000	9,000
Small	10,400	4,000	10.800
Med-lite	--	--	5.100
Medium	24,300	35,600	31,000
Intermediate	43,000	26,000	--
Upper stages	6,900	15,200	18,300
To	84,600	95,800	74,200

PROGRAM GOALS

Launch Services are a vital element in the achievement of the overall goals of the Space Science program. Expendable Launch Vehicles (ELVs) provide space science missions with safe, reliable, cost-effective access to low Earth orbit, and possess the unique capability of delivering spacecraft beyond Earth orbit to other points in the solar system and beyond.

STRATEGY FOR ACHIEVING GOALS

Payloads may be launched aboard a number of vehicles, each of which supports a discrete performance class. Small payloads are launched aboard the Pegasus XL, which is developed by the Orbital Sciences Corporation (OSC) and requires in-flight deployment from a Lockheed L1011 aircraft. The Pegasus XL is capable of delivering payloads up to approximately 1,000 pounds to low Earth orbit. The Ultra-lite launch services budget supports the Student Explorer Demonstration Initiative (STEDI) which is managed by the United States Research Association (USRA) in cooperation with NASA. Funding supports the development of two small university-developed spacecraft and the procurement of launch services. A contract for Ultra-lite launch services was signed with OSC in December 1994 to support the STEDI program. This new class of ELV will provide approximately one half the lift capacity of a Pegasus.

Medium class payloads require launch services capable of delivering up to 11,000 pounds to low Earth orbit. These missions are launched aboard the Delta launch vehicle, which is developed by McDonnell-Douglas (MDAC). These vehicles may be launched either from the Cape Canaveral Air Force Station (CCAFS) or, if a polar orbit is required. from the Vandenberg Air Force Base (VAFB). The Med-lite is a new class of launch services which will provide approximately one half the lift capacity of a Delta. Contractor selection for the new Med-lite is targeted for summer of 1995.

Intermediate class payloads require launch services capable of delivering spacecraft up to 20.000 pounds to low Earth orbit. These missions are launched aboard the Atlas launch vehicle, which are provided by the Martin-Marietta Corporation and, like the Delta, may be launched either from the east coast (KSC) or west coast (VAFB). Payloads launched aboard the Shuttle may be delivered to a higher orbit via the use of an upper stage. The AXAF mission will be launched aboard the Shuttle, and will use an Inertial Upper Stage (IUS) developed by Boeing to deliver the spacecraft to a highly elliptical orbit.

Funding for mission-unique launch services is now included under the budget request for the benefiting program. Funding support for management oversight of the entire Launch Services program rests with the Launch Vehicles Office (LVO), which is now part of the newly-formed Office of Space Access and Technology (OSAT). The LVO aggregates NASA, the NOAA, and the international cooperative ELV mission requirements, establishes appropriate acquisition strategies for purchasing firm, fixed priced launch services from the U.S. industry, and imposes the scope and level of technical oversight of the commercial ELV operators' delivery of service that reflects the criticality of the mission and the level of government resources at risk The administration, procurement, and technical oversight of launch services in the small and medium performance classes is managed by the Goddard Space Flight Center (Pegasus XL, Med-lite and Delta II). Intermediate (Atlas I/IIAS) launch services are managed by the Lewis Research Center (LeRC). Upper stages, including the AXAF IUS, are managed by the Marshall Space Flight Center (MSFC). The KSC is delegated responsibility for technical oversight of vehicle assembly and testing at the launch site by GSFC and LeRC and is responsible for spacecraft processing at the launch site.

MEASURES OF PERFORMANCE

Wind launch - November 1994	Launch delayed from mid-1994 due to technical problems with spacecraft. Launched successfully aboard Delta 11 on November 1, 1994.
SWAS launch - July 1995	Launch from KSC aboard the Pegasus XL/L1011 launch vehicle. Exact date of this launch is dependent upon successful return to flight of the redesigned Pegasus XL launch vehicle. Targeted for July 1, 1995 in summer launch window.
FAST launch - August 1995	Launch from VAFB aboard the Pegasus XL/L1011 launch vehicle. Launch delayed from mid-1994 due to technical problems with new Pegasus XL. Exact date of this launch is dependent upon successful return to flight of the redesigned Pegasus XL launch vehicle. Launch currently targeted for 1995 launch window (August 1-20).
SAC-B/HETE launch mid-late 1995	Dual payload launch from WFF aboard Pegasus XL/L1011 launch vehicle. Exact date of this launch is dependent upon successful return to flight of the redesigned Pegasus XL launch vehicle.
XTE launch - August 1995	Launch aboard a Delta 11.

SOHO launch - October 1995	**Atlas IIAS** launch delayed from July 1995 to October due to spacecraft readiness and **Atlas** launch manifest conflicts.
Polar launch - December **1995**	Launch aboard a Delta II from Vandenberg Air Force Base (VAFB) delayed from mid-**1994** due to technical problems with spacecraft. **New** launch date still **maintains** operational overlap with other GGS mission (Wind).

ACCOMPLISHMENTS AND PLANS

Planned launches for missions using the Pegasus launch vehicle are currently under review. In June **1994.** the first flight of the new Pegasus XL was aborted due to mechanical malfunctions, and future launches have been delayed until the implementation of required redesigns are completed. **This** has deferred the planned launches of FAST, SWAS and SAC-B/HETE by several months. Redesign activity by the launch vehicle developer and operator. the Orbital Sciences Corporation (OSC), **is** nearing completion. The next Pegasus flight will carry an OSC-developed commercial payload in March **1995.** First launch of the fully redesigned vehicle **is** planned for April, and will carry the Total Ozone Mapping Spectrometer (TOMS) mission developed by the Mission To Planet Earth (MTPE) program. FY **1996** funds also support initial launch services procurements for the new SMEX missions, TRACE and **WIRE,** with planned launches in FY **1997** and FY **1998.** respectively.

Ultra-lite launch services funding supports the STEDI program. Initial payload development and launch vehicle procurement begins in FY **1995.** USRA **is** currently reviewing proposals for science payloads, and will select the final two mission candidates in late January. A contract for Ultra-lite launch services **was** awarded in December **1994** to OSC in support of planned launches in early **1997.**

Med-lite funding supports the initial procurement of launch services for the FUSE mission in October **1998. This** program **was** previously baselined for a Delta 11 launch in late 2000, but **is** currently being rescoped to reduce total cost, schedule and launch services requirements. After numerous delays due to technical problems experienced during integration and test, the Wind spacecraft was successfully launched in November. These delays have also resulted in the delay of Polar to November **1995.** Other missions supported include the Explorer missions, **XTE** (August **1995)** and ACE (August **1997).**

The SOHO mission launch aboard an Atlas IIAS has been deferred by several months due to spacecraft readiness concerns and a crowded Atlas launch manifest, but **is** still scheduled for launch in **1995.** NASA has selected Boeing to provide an Inertial Upper Stage (IUS) for the *AXAF* mission, and activities have begun in support of a Shuttle launch in September **1998.**

Planetary Exploration

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — **PLANETARY EXPLORATION**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995	FY 1996	Page Number
		(Thousands of Dollars)		
• Cassini	266.600	255.000	191.500	SAT 1.2-4
Mars instruments	4.400	2.100	1.400	SAT 1.2-7
• Discovery	127.400	129.700	103.800	SAT 1.2-9
• Mars surveyor	14.600	59.400	108.500	SAT 1.2-13
• New millennium spacecraft	--	10.500	30.000	SAT 1.2-16
Mission operations and data analysis	130.700	117.200	127.800	SAT 1.2-19
Research and analysis	107.600	108.400	109.100	SAT 1.2-23
Launch services	120.600	134.800	155.700	SAT 1.2-28
Total	771.900	817.100	827.800	

Distribution of Program Amount by Installation

Johnson Space Center	4.591	4.505	4.329
Kennedy Space Flight Center	20	525	2.811
Marshall Space Flight Center	30	--	--
Ames Research Center	10.939	9.956	9.680
Langley Research Center	25	--	--
Lewis Research Center	86.480	78.190	97.457
Goddard Space Flight Center	54.895	77.330	72.868
Jet Propulsion Laboratory	428.086	480.892	465.980
Headquarters	186.834	165.702	174.675
Total	771.900	817.100	827.800

* Total Cost information is provided in the Special Issues section.

PROGRAM GOALS

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids. Within the broad goals outlined for the Space Science program. the goals of the Plane —— Exploration program are:

- To understand the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system:
- To understand the origin and evolution of the solar system by exploring, surveying. and sampling the planets and moons with robotic spacecraft; and,
- To understand if planets, including terrestrial-like planets, exist around other stars.

STRATEGY FOR ACHIEVING GOALS

The strategy of the Plane —— Exploration program has placed a balanced emphasis on the Earth-like inner planets, the gaseous giant outer planets, and the smaller bodies, including comets and asteroids. Missions to previously unexplored solar system bodies typically are at the reconnaissance level to achieve a fundamental characterization of the target of observation. Subsequent missions to the same bodies are then enabled to conduct more detailed studies. With the Magellan mapping of the Venusian terrain, the reconnaissance phase of inner planetary exploration, with the exception of Mercury, is virtually complete.

Mars has been a primary program focus due to its potential for previous biological activity and for comparative studies with Earth. The Mars Surveyor program was initiated in FY 1994 to obtain data lost from the Mars Observer mission and to resume the surface exploration of Mars. This series of small spacecraft is a level-of-effort activity that includes two launches of orbiters and landers at each flight opportunity. The first mission. the Mars Global Surveyor (MGS) will fly a small science payload, comprised of space Mars Observer instruments aboard a small, industry-developed spacecraft. Launch is planned for November 1996 aboard a Delta II launch vehicle.

The Cassini will conduct extensive investigations of Saturn, its rings and satellites, building upon the discoveries made through the Pioneer and Voyager missions. Like AXAF, Cassini was also restructured in 1992. Significant reductions in peak funding requirements and total mission life-cycle costs were achieved by simplifying the spacecraft design, streamlining mission operations, and trimming science requirements. Along with spacecraft observations. the European Space Agency (ESA)-provided

Huygens Probe will conduct in-situ atmospheric measurements of Saturn's moon, Titan. Cassini is scheduled for an October 1997 launch aboard a Titan IV launch vehicle. and will fly by Earth, Venus, and Jupiter en route to a June 2004 rendezvous with Saturn where investigations will be conducted for four years.

Funding was also provided in FY 1994 for the start of the first two Discovery missions, the Mars Pathfinder and the Near Earth Asteroid Rendezvous (NEAR). These small, low-cost planetary missions are designed to be built and flown by the science community in three years or less from new start to launch. The program stimulates innovative teaming and management arrangements between industry, university. and government partners. The Mars Pathfinder will test innovative entry. descent and landing systems, and will deliver a modest science payload to the Martian surface, including a microrover provided by the Office of Space Access and Technology (OSAT). Launch is scheduled for December 1996 aboard a Delta 11 launch vehicle. The *NEAR* mission promises to answer fundamental questions about the nature and origin of 'primitive bodies" in its one year orbit around asteroid 433 EROS. It too is scheduled to launch aboard a Delta 11 launch vehicle in February of 1996.

The New Millennium Spacecraft program is an aggressive technology demonstration effort, structured so as to precipitate a revolution in the design, development and implementation of science spacecraft and instruments for the new millennium. With objectives of increasing the capability of NASA's spacecraft and instruments while simultaneously reducing total life cycle costs of future science missions and increasing flight rates, this program represents a logical next step for NASA to take in achieving its scientific and technological goals. NASA anticipates that the first technology results could occur as early as FY 1997. with subsequent missions occurring at a rate of one or more at 12-24 month intervals.

The Mission Operations Support Office (MOSO) is maintained at the Jet Propulsion Laboratory (JPL). This program provides ground system hardware. software development and mission support for all planetary programs. At present, MOSO supports ongoing mission operations for Voyager, Ulysses and Galileo as well as final mission close out activities for the Magellan mission. The program also supports the development of generic ground system upgrades such as the Advanced Multimission Operations System *(AMMOS).*

The Research and Analysis (R&A) program defines the scientific priorities for future missions as well as maximizing the exploitation of existing data sets. The R&A program consists of three elements designed to: (1) assure that data from flight missions is fully exploited; (2) undertake complementary observational, laboratory and theoretical efforts: and (3) define scientific and technical requirements and develop technologies for future planetary missions.

Beginning in FY 1996, mission unique launch services for all Space Science missions requiring expendable launch vehicles are included as part of the OSS budget. Overall program management rests with NASA's Launch Vehicles Office (LVO). Launch services funding budgeted within Planetary Exploration include Medium-lite class launch services for future Discovery and Mars Surveyor missions: Delta launch services for Discovery (Mars Pathfinder, NEAR): and a Titan IV/Centaur for Cassini.

BASIS OF FY 1996 FUNDING REQUIREMENT

CASSINI DEVELOPMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Cassini development*	266.600	255,000	191,500

• Total Cost information is provided in the Special Issues section

PROGRAM GOALS

Building on the discoveries made by the Pioneer and Voyager missions, the Cassini Program will provide unprecedented information on the origin and evolution of our solar system, and will help determine how the necessary building blocks for the chemical evolution of life are formed elsewhere in the universe. The Cassini mission will conduct a detailed exploration of the Saturnian system including: 1) the study of Saturn's atmosphere, rings and magnetosphere; 2) remote and in situ study of Titan: 3) the study of Saturn's icy moons: and 4) a Jupiter flyby to expand our knowledge of the Jovian System. In conjunction with Galileo's study of the Jovian system. Cassini should also provide much insight as to how and why the large. gaseous outer planets have evolved much differently than the inner solar system bodies.

STRATEGY FOR ACHIEVING GOALS

Cassini is scheduled for launch in October 1997 aboard a Titan IV launch vehicle. An extensive cruise period is required to reach Saturn, during which the spacecraft will fly by Venus, Earth, and Jupiter to gain sufficient velocity to reach its destination. Upon arrival in June 2004, the spacecraft will begin a four year study of the Saturnian system that will provide intensive, long-term observations of Saturn's atmosphere, rings. magnetic field, and moons. In conjunction with the observations conducted by the spacecraft, the European Space Agency (ESA) - provided Huygens Probe will be injected into the atmosphere of Saturn's moon Titan. The probe will conduct in-situ physical and chemical analyses of Titan's methane-rich, nitrogen atmosphere that is a possible model for the pre-biotic stage of the Earth's atmosphere. The Cassini radar will map of most of Titan's surface.

The program was restructured in 1992 in response to downward revisions of the future funding projections for NASA programs. Significant changes were made to the spacecraft design to reduce program costs and improve mass and schedule margins, although the science payload remains essentially intact. The Jet Propulsion Laboratory (JPL) is responsible for overall management of the program, and the majority of the spacecraft and ground system are being developed inhouse. The Titan IV/Centaur launch vehicle is being purchased by NASA from the Department of Defense (DOD) as part of an existing contract between the Air Force and Martin-Marietta: the Radioisotope Heater Units (RHUs) and Radioisotope Thermoelectric Generators (RTGs) are being procured by NASA from the Department of Energy: the European Space Agency (ESA) is providing the Huygens

probe: and the Italian Space Agency (ASI) is contributing the High Gain/Low Gain Antenna for the spacecraft. There are twelve science instruments on the orbiter and six on the probe from international Principal Investigators (PIs).

MEASURES OF PERFORMANCE

Spacecraft subsystem Critical Design Reviews (CDR) - May 1994	Detailed review of Propulsion Module Subsystem (PMS) and Command & Data Handling (C&DH) subsystem designs to assess maturity. compatibility with established interfaces (structural, thermal, etc.) established during System level CDR
Ground System Critical Design Review (CDR) - February 1995	Review determines ground system hardware/software for maturity, compatibility with external interfaces (spacecraft, tracking, PIs, etc.) and ability to meet mission objectives
Complete Instrument Final Interface Requirements and Design Reviews (FIRDR) - March 1995	Provide approval to finalize design and begin full scale hardware development
Development Test Model Static and Modal Tests - April thru November 1995	Simulates and tests spacecraft launch environment to assure its survivability from acoustic and dynamic stresses.
Huygens Probe Critical Design Review (CDR) - September 1995	Confirms that the detailed design of ESA-provided hardware is compatible with all established spacecraft interfaces (structural, electrical, thermal, etc.) and is of sufficient detail and maturity to achieve planned delivery date.
Engineering Model Probe delivery from ESA - February 1996	Engineering model delivery to JPL is critical requirement for interface testing with the spacecraft.
Start System Level Tests - May 1996	Integration, test and checkout of flight hardware and instruments.
Deliver Flight Model Science Instruments - July 1996	Delivery of flight model instruments to JPL for integration with the spacecraft
Start Spacecraft Environmental Tests - October 1996	Tests entire spacecraft performance in a simulated mission environment to assure proper operation in space.
Ship spacecraft to KSC - April 1997	Complete system level integration and test activities. Begin integration with Titan IV/Centaur launch vehicle at Kennedy Space Center (KSC).
Spacecraft launch - October 1997	Development phase complete. Initiate spacecraft checkout and cruise operations.

ACCOMPLISHMENTS ANI F

In FY 1994, Cassini transitioned from the design phase to fabrication and test. Instrument Critical Design Reviews (CDRs) were completed, and fabrication of engineering model hardware is underway. Engineering models for the two U.S.-developed Huygens Probe instruments were completed and delivered in June. The majority of the spacecraft subsystem CDRs were completed, and fabrication of breadboard and engineering model hardware began. The High Gain Antenna (HGA) CDR, and the Huygens Probe Hardware Design Review (by ESA) were also completed. In addition, fabrication of flight subsystems and cabling was started.

All remaining CDRs for the Cassini spacecraft subsystems will be completed in FY 1995. Spacecraft subsystem integration will continue through the first half of FY 1995, and will be conducted in parallel with initial spacecraft systems testing such as static loads, vibration, acoustic and pyro shock testing. Integration and test of the science instruments for both the orbiter and probe will also continue in FY 1995. Delivery of the probe instrument flight units is scheduled for mid FY 1995 to allow ESA sufficient time to conduct their own system level testing of the Huygens Probe prior to final delivery to Kennedy Space Center (KSC) in FY 1997. Ground System hardware deliveries will continue in conjunction with the development and test of flight software for the launch and cruise phase of the prime mission.

In FY 1996, Cassini subsystem hardware fabrication and testing will be completed. The Huygens Probe engineering model will be delivered to the JPL in February. Spacecraft subsystems and instrument flight models will be delivered to the spacecraft assembly facility in the last quarter of FY 1996 in support of system level testing which will continue into FY 1997.

BASIS OF FY 1996 FUNDING REQUIREMENTS

MARS INSTRUMENTS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Mars instruments..	4.400	2,100	1,400

PROGRAM GOALS

The study of Mars is of major interest to NASA and the international science community due to its potential for previous biological activity and for comparative studies with the Earth. Therefore, NASA is developing a portion of the science payload to fly aboard a Russian spacecraft and lander mission which will obtain descent and surface imagery, in-situ seismology, soil composition and meteorology measurements. Instruments developed by NASA will determine the presence of atmospheric and/or soil oxidants which theoretically caused the rapid destruction of the organic material tested on the Viking mission.

STRATEGY FOR ACHIEVING GOALS

Mars '94 is a Russian mission comprised of an orbiter. two surface penetrators. and two hard landers to be deployed on the Martian surface. Each lander will carry a variety of science instruments provided by several international partners including Germany, Finland, France and the US. The Jet Propulsion Laboratory (JPL) will provide two Mars Oxidation (MOx) experiments, one for flight aboard each of the two original landers. To conserve mass, power and space, these experiments will share common electronics subsystems with German and Russian instruments. U.S. scientists are also involved in many of the other science instruments provided by our foreign partners.

MEASURES OF PERFORMANCE

Deliver flight model MOx instruments - May 1994	Completed development of two MOx experiments. Shipped to Russia for final integration and test in support of planned launch in October 1994. Hardware subsequently returned for refurbishment due to launch delay.
Deliver MOx Instruments - April 1995	Complete refurbishment of MOx instruments with upgraded electronics. Ship to Russia for final integration with rest of science payload in support of October 1996 launch.
Deliver MOx Sensor Heads - May 1996	Provide two refurbished MOx sensor heads to Russia for spacecraft integration.
Spacecraft launch - October 1996	Development phase complete. Initiate mission operations.

ACCOMPLISHMENTS AND

During FY 1994. final integration and testing of the two U.S. science instruments was nearing completion, and shipment of the flight units to Russia was scheduled for May 1994 for integration with the rest of the science payload. However, technical problems encountered by the Russians delayed project completion beyond the October 1994 launch opportunity. This has required a two year launch delay to October 1996. This has necessitated refurbishment of the MOx instruments and replanning the delivery to Russia for final integration with the rest of the science payload. FY 1995 funding provides ongoing support for the U.S. science investigators associated with all aspects of the science payload. The MOx instruments will be refurbished with upgraded electronics and shipped to Russia in May 1995 for spacecraft integration. The MOx sensor heads will also be refurbished and shipped to Russia for spacecraft integration in May 1996 for an October 1996 launch. The one year prime mission will begin upon arrival at Mars in September 1997. JPL has been designated to handle data processing and dissemination of MOx data from the Mars '94 mission. The FY 1996 funding is provided to establish science data formatting, archival and dissemination requirements prior to initiation of the prime mission in September 1997.

BASIS OF FY 1 FUNDING REQUIREMENT

DISCOVERY PROGRAM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Mars pathfinder	60,800	77.500	35,900
Near earth asteroid rendezvous	66,600	52.200	31,300
Future missions	---	---	36,600
Total	127.400	129,700	103,800

* Total Cost information is provided in the Special Issues section

PROGRAM GOALS

The Discovery program reflects the agency's commitment to ensure a continuous stream of new planetary science data and more frequent access to space, both of which are critical requirements for a robust planetary science program in the future. Missions will perform high-quality scientific investigations of solar system bodies, including inner solar system planets (i.e. Mercury, Venus and Mars). comets and asteroids. The program is intended to accomplish these Investigations while enhancing the U.S. return on its investment by aiding in the transfer of new technologies to the private sector. The program also seeks to enhance public awareness of. and appreciation for, space exploration and to provide educational program opportunities. It seeks to further reduce total mission/life cycle costs and improve mission performance through the use of new technology and through control of design. development, launch and operations costs.

STRATEGY FOR ACHIEVING GOALS

Discovery missions are designed with focused science objectives that can be met with limited resources. Total development costs are not to exceed $150 million in constant FY 1992 dollars, and development schedules are limited to three years or less. Total mission costs are further constrained by limiting launch services requirements to a Delta II or Med-Lite launch vehicle. The current Discovery missions, Mars Pathfinder and Near Earth Asteroid Rendezvous (NEAR), are consistent with these criteria.

The Mars Pathfinder mission was approved as a new start in FY 1994 and is being conducted as an in-house effort at the Jet Propulsion Laboratory (JPL). The mission is designed to demonstrate the cruise, entry, descent, and landing system approach that will be used in future missions to place a network of small science landers on the Martian surface. Pathfinder will carry three science instruments and a technology development microrover separately funded by the Space Access and Technology program. The multispectral stereo Imager for Mars Pathfinder (IMP)will characterize the Martian surface morphology and geology at a one-meter resolution. An Alpha-Proton X-ray Spectrometer (APXS) will obtain information on the elemental composition of Martian

rocks and soil. This instrument will be carried aboard the microrover. An Atmospheric Structure Instrument and Meteorology package (ASI-Met)will obtain information on the structure of the Martian atmosphere from measurements during entry and descent, and will obtain in-situ meteorology information while deployed on the Martian surface. The lander will also deploy and operate the microrover flight experiment to evaluate the effects of the Martian surface conditions on the rover design and its ability to deploy and operate science instruments. Portions of the science instruments are being provided by Germany and Denmark. Launch is scheduled for December 1996 aboard a Delta 11 launch vehicle. Communications will be via the Deep Space Network (DSN) and mission operations supported by JPL's Multimission Operations Systems Office (MOSO).

NEAR was also approved as a new start in FY 1994, and is being conducted as an in-house development at the Applied Physics Laboratory (APL) with many subcontracted subsystems. Tracking and navigation support will be provided by JPL. This spacecraft will conduct a comprehensive study of the near Earth asteroid 433 EROS, including its physical and geological properties and its chemical and mineralogical composition. The spacecraft carries five scientific instruments. The Multispectral Imager (MSI) will provide global imaging coverage as well as detailed views of the asteroid at resolutions as high as one to two meters to reveal details of the geologic processes that have affected its evolution: the X-Ray/Gamma-Ray Spectrometer (XGRS) will provide a chemical analysis by measuring several dozen key elements: the Near Infrared Spectrometer (NIS) will determine the mineral composition of the asteroids surface: and the Magnetometer, together with radio science, will help characterize its internal structure. The Laser Altimeter (LIDAR)will help provide an asteroid shape, distinguish albedo from topographic variations, and measure surface morphology. Launch will be on a Delta 11 launch vehicle in February 1996. The EROS launch opportunity requires an accelerated development schedule for NEAR of *only 27* months.

MEASURES OF PERFORMANCE

Mars Pathfinder:

Delta Design Review (DDR) - July 1994	Emphasis on spacecraft Entry, Descent and Landing (EDL) subsystem designs which were revised to accommodate new entry trajectory for lander.
System level Critical Design Review (CDR) - September 1994	Confirms that the project system, subsystem. and component designs are of sufficient detail to allow for orderly hardware and software manufacturing, integration and testing, and represents acceptable risk. Successful completion freezes the design prior to initiation of fabrication, integration and test.
Flight System Assembly and Test Review - April 1995	Review ensures that flight system hardware is ready to proceed into assembly and test phase
Complete Instrument Deliveries - September 1995	Last instruments delivered to JPL for integration with spacecraft hardware
Flight qualification tests - December 1995	Performance testing of major elements of Entry. Descent and Landing (EDL) subsystem (Airbag, aeroshell, chute, etc.) to assure survivability of payload during Mars landing

Flight hardware deliveries - January 1996	Flight model spacecraft subsystems [aeroshell. chute, bags, microrover. etc.) fabrication and testing completed. Initiate system level integration.
Re-ship Review (PSR) - August 1996	Ensure spacecraft is ready for shipment to Kennedy Space Center (KSC) for integration with Delta 11 launch vehicle. Shipment to KSC planned for September.
Launch - December 1996	Development complete. Initiate spacecraft checkout and mission operations.
<u>Near Earth Asteroid Rendezvous:</u> Technical and Cost Review - December 1993	Detailed review determined readiness to proceed with mission design and development
Preliminary Design Review (PDR) - April 1994	Review confirmed that proposed project baseline meets all program-level performance requirements and represents acceptable level of cost and technical risk.
Selection of Science Teams - September 1994	Science teams selected to perform experiments and observations with facility instruments.
Critical Design Review (CDR) - November 1994	Confirmed that the project system, subsystem and component designs are of sufficient detail and maturity, are compatible with established interfaces (structural, thermal, etc.) and ready for initiation of fabrication, integration and testing.
Flight hardware deliveries - June-August 1995	Flight model spacecraft subsystems and instruments completed. Begin system level integration and test phase.
Pre-ship Review (PSR) - January 1996	Ensure spacecraft is ready for shipment to Kennedy Space Center (KSC) for integration with the Delta 11 launch vehicle
Launch - February 1996	Development phase complete. Initiate spacecraft checkout/cruise operations.

ACCOMPLISHMENTS AND PLANS

Mars Pathfinder development activities *are* proceeding well. A Delta Design Review (DDR) of the spacecraft was completed in July 1994. and instrument CDRs are currently underway. Flight hardware and software development is proceeding within cost and on schedule for a December 1996 launch. *All* major flight system design issues are resolved, and planned tests have been successfully accomplished. Mars Pathfinder flight model spacecraft subsystems, instruments and microrover are scheduled for delivery by mid-late 1995 to initiate system level integration and testing at the JPL. Ground system developments such as flight software and mission sequences will also be supported in FY 1995. Mars Pathfinder will complete integration and test activities in preparation for a December 1996 launch. Completion of microrover tests in a Mars simulated environment will be conducted, and

flight qualification tests will be completed in December 1995. Flight Aeroshell. parachute, and airbags. will be delivered in the first half of FY 1996. A Pre-Ship Review (PSR) is scheduled for August 1996 prior to shipment to KSC in September and a December 1996 launch aboard a Delta 11.

The NEAR mission successfully completed its system PDR in April 1994, followed by a CDR in November. Fabrication of spacecraft and instrument subsystems is currently underway and will continue through June or July 1995. Flight instrument and spacecraft subsystem deliveries are scheduled for completion by late FY 1995 to support system-level integration and test activities in FY 1996. System-level integration begins in June 1995, followed by environmental testing in December. All activities remain on schedule in support of the February 1996 launch aboard a Delta 11.

Additional resources are requested in FY 1996 and beyond to initiate development of future Discovery missions. An Announcement of Opportunity (AO) was released in August 1994 for candidate missions. Proposals were received in October. with selections targeted for late January. Missions will be selected on the basis of overall scientific merit, with emphasis on providing increased opportunities for participation by industry and universities. Funding supports a planned launch rate of one per year beginning in FY 1999 aboard Delta 11 or Med-Lite launch vehicles.

MARS SURVEYOR PROGRAM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Mars global surveyor	14,600	58,000	58.200
Future missions	---	1.400	50,300
Total	14.600	59.400	108.500

• Total Cost information is provided in the Special Issues section

PROGRAM GOALS

Mars has long been a primary focus of the Planetary Exploration program due to its potential for previous biological activity and for comparative studies with the Earth. The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. The goals of the mission are to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation topography, gravity and magnetic fields of Mars.

STRATEGY FOR ACHIEVING GOALS

This program began in FY 1994 with the Mars Global Surveyor (MGS) mission, which will obtain a majority of the expected science return from the lost Mars Observer mission. The orbiter will fly a science payload comprised of spare Mars Observer instruments aboard a small, industry-developed spacecraft. Launch is planned for November 1996 aboard a Delta II launch vehicle. This mission is to be succeeded by a series of small communications orbiters and landers which will make in-situ measurements of the Martian climate and soil composition. The first of these missions is scheduled for launch in December 1998. Technology developments from the Discovery mission, Mars Pathfinder, will be optimized to reduce mission costs and technical risk associated with development of the Mars Surveyor landers. Design concepts for these missions are currently being worked in conjunction with the International Mars Exploration Working Group. Current planning assumes two launches in December 1998 and two launches in February 2001. All four launches are baselined to use Med-Lite launch vehicles, which provide approximately one half the lift capacity of a Delta 11.

MEASURES OF PERFORMANCE

Instrument Review Panel - February 1994	Proposed subset of Mars Observer instruments selected for incorporation into Mars Global Surveyor (MGS). Refurbishment/retest activities initiated.
MGS spacecraft contractor selection - July 1994	Martin Marietta selected as MGS spacecraft contractor and systems integrator.
Mission Qperations System Preliminary Design Review (PDR) - September 1994	Review of ground system hardware/software designs was conducted to confirm that proposed operations baseline meets all mission objectives, is compatible with established interfaces, and represents an acceptable level of cost, schedule and technical risk.
Program Confirmation Review - February 1995	Confirms that overall budget/schedule baseline is adequate to proceed with mission development.
Spacecraft System Critical Design Review (CDR) - May 1995	Confirms that spacecraft system, subsystem and component designs are sufficiently mature, compatible with established interfaces (structural. thermal, electrical, etc.), and represent appropriate levels of cost, schedule and technical risk.
System Test Readiness Review (STRR) - October 1995	To assure the flight system and required test capabilities are in place and ready for pre-flight testing.
Instrument Calibration and Test - December 1995	Instrument integration completed. Instruments operated under simulated flight conditions to validate/characterize performance against design specifications.
Instrument deliveries - February 1996	Instruments begin delivery to Martin-Marietta for integration with spacecraft prior to initiation of system level testing.
System Acceptance Review - August 1996	Assure that flight hardware integration is complete and ready for Anal acceptance tests.
Pre-Ship Review (PSR) - October 1996	Formal review approving test results and recommending mission launch.
Launch - November 1996	Development phase completed. Initiate spacecraft checkout and cruise operations.

CO AND PLANS

In FY 1994, $14.6 million was reallocated via an operating plan adjustment to initiate development of the Mars Global Surveyor (MGS). The science payload, a subset of the original Mars Observer instruments, was selected in February and initial refurbishment activities began in mid-1994. Martin-Marietta was selected as the spacecraft contractor in July, and detailed design activities were begun in preparation for the October Preliminary Design Review (PDR). In FY 1995. MGS will continue refurbishment of residual Mars Observer instrument spares. Detailed design activities will continue in support of the spacecraft Critical Design Review (CDR) in May. Hardware fabrication and assembly will be conducted throughout FY 1995 to prepare for systems testing to begin in early FY 1996. Instrument testing and calibration activities will be completed in December 1995. Instruments will be integrated onto the spacecraft in February 1996. System level integration and testing will be conducted throughout the year, and a Re-Ship Review (PSR) will take place in October in preparation for a November 1996 launch.

Funding is also provided to Initiate development of payloads planned for launch in the December 1998 opportunity. These tentatively include a communications orbiter and a Mars lander, both launched aboard Med-Lite launch vehicles. There will be a Request for Proposals (RFP) released in January 1995 requesting design proposals for the orbiter and lander segments of the 1998 mission. The Announcement of Opportunity (AO) for flight instrument proposals will follow shortly thereafter.

BASIS OF FY 1996 FUNDING REQUIREMENT

NEW MILLENNIUM SPACECRAFT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
New millennium spacecraft development*	---	10,500	30,000

* Total Cost information is provided in the Special Issues section

PROGRAM GOALS

New Millennium Spacecraft is an aggressive technology development and demonstration program designed to precipitate a revolution in the design, development and implementation of science spacecraft and instruments. Shrinking budgets require lower mass, affordable spacecraft and instruments to reduce development, launch services and mission operations costs. Continuing business as usual in a constrained budget environment will ultimately lead to reduced science capability and degraded science return, fewer missions and shrinking frontiers. Enhancing the launch rate of new space missions requires the infusion of innovative new technologies, new mission concepts and new ways of doing business.

Primary objectives of the program are to increase the performance capabilities of spacecraft and instruments while simultaneously reducing toal costs of future science missions, thereby increasing the science mission flight rate. Key areas to be addressed include reducing the (launch)volume and weight of the spacecraft and instruments -- to enable missions to be launched on smaller, less-costly launch vehicles -- and increasing overall spacecraft autonomy and performance, which will reduce operations cost and increase science return. Aggressive, systems-level flight demonstration of key technologies will promote rapid infusion of these technologies into future scientific missions, while simultaneously mitigating the risk traditionally associated with using new technologies in these missions. The program is expected to benefit both future space exploration and Earth sciences programs.

STRATEGY FOR ACHIEVING GOALS

The program will be implemented as a partnership between the Office of Space Science (OSS) and the Office of Space Access and Technology (OSAT), working closely with the science community to highlight key scientific challenges to be addressed in the new millennium, and with the broad technology community (NASA, other government agencies, industry and academia) to identify key technology areas to address these challenges. The program will encompass spacecraft components and subsystems, science instruments and streamlined design, development and qualification methodologies. Exploitation of key technologies will be optimized by combining the efforts of the New Millennium Spacecraft program with ongoing technology focused activities being conducted by OSAT.

New Millennium spacecraft utilizes a systems approach which tightly integrates several focused technologies at once. Technologies which contribute most significantly to overall program goals will be selected for further development and adpatation to science mission requirements and will be validated by a series of flight technology demonstration missions occurring at a rate of one or more per year, with initial flights planned for the 1997-98 timeframe. Although the primary purpose of these missions will be to validate the high priority technologies needed to enable future science missions, the demonstration flights will also. to the maximum extent practical, incorporate a modest science payload to exploit scientific targets of opportunity. In implementing the strategy, NASA will place a strong emphasis on innovative management approaches which will assure synergistic teaming with industry. academia, and other government agencies. The Jet Propulsion Laboratory (JPL) will manage program implementation.

MEASURES OF PERFORMANCE

Science Working Group Established - August 1994	Identification of New Millennium vision: Scientific challenges to be addressed in the 2000-2010 timeframe
Implementation Plan Drafted - December 1994	Proposed implementation process identified (preliminary)
Technology Workshop - February 1995	Review proposed implementation process with industry. academia, other government agencies; Broad identification of emerging technologies of interest
Implementation Plan (Final) - February 1995	Implementation process finalized and approved
Preliminary Mission Set Provided, Evaluated, Downselected - April 1995	Candidate sets of demonstration missions identified. each set addressing key technologies of interest, as well as possible scientific targets of opportunity; Downselect from approximately 12 to 4 mission sets
Refined Mission Set Provided, Evaluated, Downselected - mid-1995	Approximately four mission sets evaluated in detail: Downselect to one or two high priority mission sets
Select Partners - mid-1995	Identify partners from industry. academia, other government agencies to form Integrated Product Development (IPD) teams
Technology Demonstration flights - 1997, 1998, 1999	Specific Dates TBD: Will depend on results of process to identify high priority technologies and integrate them into specific demonstration missions

ACCOMPLISHMENTS AND PLANS

Emphasis to date has been on drafting an implementation plan outlining the overall process for accomplishing the program within proposed cost and schedule guidelines. In FY 1995, the Implementation Plan will be finalized. and key technologies will be selected and integrated with science opportunities into an initial set of mission candidates. These mission candidates will be reviewed for technological and scientific merit, and will ultimately be downselected to two finalists. NASA will work with industry, other government agencies, and universities to form Integrated Product Development (IPD) teams for development of technologies that have broad application for New Millennium missions. Project IPD teams will also be established which will be responsible for development and implemention of the selected missions.

In FY 1996, each of the missions selected will initiate detailed design and development activities in support of planned technology demonstration flights in the FY 1997-98 timeframe. Concurrent with the development of these specific missions, funding will also support other IPD teams which will initiate focused technology activities for incorporation into future technology demonstration missions.

BASIS OF FY 1996 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Galileo operations	59,400	70,700	75,100
Magellan operations	11,800	--	--
Voyager neptune data analysis	4,300	--	--
Near earth asteroid operations	--	--	3,300
Planetary flight support	55,200	46,500	49,400
Total	130,700	117,200	127.800

PROGRAM GOALS

The Mission Operations and Data Analysis (MO&DA) program is a key element to the achievement of the overall goals of the Office of Space Science (OSS). Funding supports spacecraft operations as well as the acquisition, processing, analysis and dissemination of science data while maximizing overall program efficiency and minimizing costs.

STRATEGY FOR ACHIEVING GOALS

The Planetary Flight Support line maintains the Mission Operations Support Office (MOSO)at JPL. This program provides ground system hardware, software development and mission support for all planetary programs. The planetary flight support activities are those associated with the design and development of planetary ground operation systems for multiple missions, and other activities that support the mission control, tracking, telemetry, and command functions through the Deep Space Network (DSN) for all planetary spacecraft. At present, MOSO supports ongoing mission operations for Voyager, Ulysses and Galileo as well as final closeout activities for the Magellan mission. The program also supports the development of generic ground system upgrades such as the Advanced Multimission Operations System (AMMOS). This new capability is designed to improve our ability to monitor spacecraft systems, thereby reducing workforce levels and increasing operations efficiencies for Cassini and other future planetary missions. New missions such as the Mars Pathfinder and Mars Surveyor program will work closely with the Planetary Flight Support Office to ensure the most efficient use of current ground system capabilities, to minimize both ground systems development and operational requirements and to reduce overall mission operations costs.

MEASURES OF PERFORMANCE

Galileo	
Asteroid Ida Data Retrieved - June 1994	Transmit to Earth all Ida science data and imagery including the first ever discovery of an asteroid satellite (Dactyl).
Comet Shoemaker-Levy 9 Observations - July 1994	Acquisition/processing/analysis of imagery showing the actual impacts of Shoemaker-Levy 9 into Jupiter.
Galileo probe release and orbit maneuver - July 1995	Separate the Galileo orbiter and probe and maneuver the orbiter to a deflection parallel trajectory to relay probe data at Jupiter entry.
Galileo insertion into Jupiter Orbit - December 1995	Maneuver the orbiter into orbit around Jupiter. Initiation of prime mission operations.
Return Probe Data - March 1996	All probe data sent to and stored on the orbiter transmitted to Earth. Critical element of overall mission objectives.
Return Io and Jupiter Encounter Data - July 1996	Transmit to Earth, science data and imagery from encounters with Jupiter and its moon Io.
Ganymede Encounter - September 1996 Ganymede Encounter - November 1996 Callisto Encounter - December 1996	Transmit all science data and imagery from the Ganymede and Callisto encounters in 1996 to Earth.
Near Earth Asteroid Rendezvous	
Launch - February 1996	To rendezvous with the asteroid EROS, NEAR must launch in February 1996. Another launch opportunity occurs 11 months later to a different near Earth asteroid.
Planetary Flight Support	
Galileo Phase 1 Development Completed - September 1994	Complete upgrade of multi-mission software to support orbit insertion and probe release.
First Cassini ITL Build - April 1995	Hardware and telemetry and command software build to support start of Cassini spacecraft Integration and Test Laboratory (ITL) activities.
Modify Multi-Mission Ground System for Mars Pathfinder - September 1995	Complete development and testing of modification to the multi-mission ground system to support Mars Pathfinder mission.

Galileo Phase II Development - November 1995	Complete development and testing of modifications to software to support probe data return, Jovian orbit operations and data processing.
Cassini Assembly, Test and Launch Operations (ATLO) hardware/software development - January 1996	Complete critical hardware/software components of Cassini ground system required to support start of Cassini spacecraft ATLO and to update ITL build.
Begin Cassini Re-Launch Operations Support - August 1996	Initiate pre-launch software development for telemetry, command mission control, data management, and multi-mission spacecraft analysis system in support of flight operations.

ACCOMPLISHMENTS AND PLANS

Galileo was launched in October 1989 and is nearing completion of its six-year journey to Jupiter. In October 1991, the spacecraft returned the first detailed images ever obtained of an asteroid -- Gaspra. Galileo encountered a second asteroid, Ida, in August 1993. This encounter also provided the unexpected discovery of the first ever lunar body of an asteroid, Ida's moon Dactyl. Galileo also participated in the Shoemaker-Levy 9 Jupiter impact observations in July 1994. As the *only* observing platform with a direct line of sight to the impact area, Galileo provided valuable scientific data for the event. Downlink of observations obtained will be completed by February 1995. Failure to deploy the High Gain Antenna (HGA) required a rebaselining of the mission for use of the Low Gain Antenna (LGA) only. Development is continuing on the changes in mission design and DSN coverage required to support the new mission requirements. New flight and ground software are being developed to achieve the majority of Galileo's objectives using only its Low Gain Antenna. This is being achieved at a cost lower than originally estimated. Galileo will release the atmospheric probe in July 1995 and initiate the Jovian tour the following December. The Orbiter will begin its 23 month study of the Jovian system, orbiting the giant planet 11 times. During 1996, Galileo will return the probe data as well as new science and images from Jupiter and encounters with the four Galillean satellites, Io, Ganymede, Europa. and Callisto.

The Magellan spacecraft was launched in May 1989. Since its arrival at Venus in August 1990, the spacecraft's radar mapped approximately 98% of the planet's surface to a ground resolution of about 150 meters. The spacecraft successfully completed an aerobraking experiment to circularize the orbit in the summer of 1993. The FY 94 funding covered the completion of operations of the spacecraft and the Venus Data analysis program. After a final windmill experiment into the lower Venusian atmosphere in October 1994. communications with the spacecraft were terminated as planned.

The Voyager-2 flyby of Neptune in August 1989 provided our first detailed images of this distant planet as well as previously unknown moons and geyser-like surface eruptions on Triton. Support for analysis of this data has continued since FY 1990. Due to budget constraints in FY 1995. the data analysis program is unfunded beyond FY 1994. Both Voyager 1 and Voyager 2 operations are now supported as part of the space physics MO&DA program, and continue to acquire data on the interplanetary medium as they exit the solar system and move toward the heliopause.

The NEAR mission began the development phase in December 1993 with a preliminary design review in April 1994. NEAR completed critical design review in November 1994. Testing and integration begins June 1995. The NEAR spacecraft will launch from Cape Kennedy on a Delta II in February 1996. It will orbit the sun to two astronomical units and fire its bipropellant system at aphelion in March 1997. In January 1998 it swings by the Earth to achieve the proper inclination to the elliptic plane to rendezvous with EROS. In January 1999. NEAR comes within 1000 km of EROS and fires its thrusters several times to orbit the asteroid. For the next year it will take measurements of EROS at various orbit altitudes. Spacecraft operations will be completed in January 2000.

Planetary Flight Support funding supports the development of ground system capabilities required for Galileo prime mission operations. Additional ground system development will continue in preparation for the Cassini launch in October 1997. Development of the Advanced Multimission Operations System (AMMOS) ground system upgrade will also continue with further software development and testing activities leading to operational capability in time for Cassini and subsequent planetary missions. Work will also proceed with the Discovery and Surveyor development teams to ensure support for these missions.

RESEARCH AND ANALYSIS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Supporting research and technology	82,300	83,300	83,000
Advanced technology development	25.300	25,100	26,100
Total	107,600	108,400	109,100

PROGRAM GOALS

The Research and Analysis (R&A) program defines the scientific priorities for future missions as well as maximizing the exploitation of existing data sets. The R&A program consists of three elements designed to: (1) assure optimal access to and utilization of planetary science data: (2) undertake complementary observational, laboratory and theoretical efforts; and (3) define scientific and technical requirements and develop technologies for future planetary missions.

STRATEGY FOR ACHIEVING GOALS

Supporting Research and Technology (SR&T) funds support basic and applied research across a wide variety of planetary science disciplines. These include planetary astronomy, planetary geology/geophysics, planetary materials/geochemistry, planetary atmospheres, exobiology and interdisciplinary studies. Planetary astronomy supports observations from ground-based telescopes of solar system bodies, with emphasis on outer planets, comets, and asteroids. Funding also supports continued operation of the Infrared Telescope Facility (IRTF) at Mauna Kea, Hawaii. Planetary atmospheres research studies the properties of other planetary atmospheres (e.g. Venus, Jupiter, Saturn, Uranus, Neptune) which can aid us in better understanding our own weather and climate. Planetary geology/geophysics studies surface processes, structure, and history of solar system bodies. Planetary materials/geochemistry studies the chemistry, composition, age and physical properties of solid material in the solar system through the study of returned lunar cosmic dust, samples, and meteorites. The operation of the Lunar Curatorial Facility is also supported by this activity. Exobiology uses space and ground-based opportunities to study the cosmic evolution of biogenic compounds, prebiotic evolution, and the evolution of primitive and advanced life forms. The program examines these processes in the environments in which they occurred, including Earth, the planets of our solar system and elsewhere in the universe. Ongoing development of the Planetary Data System (PDS), which archives all mission data products in a manner promoting and facilitating their use by the scientific community is also supported.

Interdisciplinary studies such as the Origins of Solar Systems program examine the interrelationship between all types of planetary science and astrophysical data. These studies lead to the development and test of new theories regarding the origin and evolution of our solar system. Advanced techniques and technologies for light collection, adaptive optics and light detection are

supported using the twin 10-meter telescopes of the Keck Observatory at Mauna Kea, Hawaii. A major goal is to enable the detection of planets around other stars.

Advanced Technology Development (ATD) supports the definition of future planetary missions to ensure technical and scientific viability as well as consistency with the overall strategic planning and scientific objectives of the Solar System Exploration program. Funds are also provided for early definition of new science instruments to reduce the cost, mass and volume as well as to provide enhanced capabilities of future science payloads.

MEASURES OF PERFORMANCE

Investigate the loss of volatiles from the atmosphere of Mars over geologic time, in the light of new atomic and molecular data and a new understanding of loss processes (Ongoing)	Hydrogen, oxygen. nitrogen, carbon and other constituents are critical in the process of evolution of the Martian atmosphere and climate. This study is directly related to the question of whether the early atmosphere of Mars was denser, warmer and wetter. and therefore whether Mars could have been the abode of primitive life
Investigate the production of hydrocarbon ions in the auroral region of Jupiter by impact of charged particles, in the light of a new atomic and molecular data (Ongoing)	A continued investigation of hydrocarbon ion chemistry in the ionosphere of Jupiter. The work is important because hydrocarbon ion chemistry, driven by auroral particle impact, is probably a significant process in the production of the heavier hydrocarbon molecules that form Jupiter's polar haze
Determination of the likelihood that a planet would be habitable (Ongoing)	Research will focus on the necessary atmospheric ingredients for a liquid water world, how evolution of the planet's sun alters the circumstellar "habitable distance" in which liquid water is maintained, and the probability of planets occurring the proper distance from the sun
Continue long-term astrometric searches for evolved planetary systems (Ongoing)	Long-term observational programs are in place to monitor several hundred nearby stars for the slight change in relative velocity or in position caused by the orbital motions of planets in orbit about the target star. Extremely high precision measurements are required to conduct these sensitive searches which are presently the only means of detecting planetary systems such as ours even around nearby stars

Begin observations with the Keck Observatory for the Astronomical Studies of Extrasolar Planetary Systems (ASEPS) and general planetary astronomy programs - September 1996	ASEPS activities are to detect extra-solar planetary systems, to understand their formation and evolution and to characterize individual planets. Other Keck activities will be the discovery and characterization of faint, small bodies in our solar system
Complete a two year data analysis program of the data sets acquired of the comet Shoemaker-Levy 9 collision with Jupiter - September 1996	This study will advance our scientific understanding in the areas of: the structural and chemical composition of impacting bodies; the chemical. physical, and thermal structure of the Jovian atmosphere and interior: the interaction of the Jovian magnetosphere with cometary dust and grains; and the physics of the entry phenomena
Developing a self replicating system, a model for Earth's earliest life - September 1996	Ribonucleic Acid (RNA) catalytic capabilities can now be evolved in a test tube with manipulation. Work is directed to develop an RNA capable of self-replication and mutation, which would be the first demonstration of life based solely on RNA
The synthesis of biologically important compounds from abiotic chemical processes operating in hydrothermal vents - September 1996	High pressure-temperature vessel are being built to test theories of abiotic synthesis of important biological compounds. Finding organic compounds would support the theory that hydrothermal vents are where life evolved on Earth

Phase A/B Studies:

Mars Surveyor Landers:	September 1994 - phase B1 (early definition phase) study complete April 1995 - phase B2 (definition phase) study complete
Pluto Flyby:	Phase A study in progress (conceptual design) FY 1997 - planned phase B (definition study)
Rosetta:	Pre-phase A study in progress (program formulation/ mission needs) FY 1996 - planned phase A (conceptual design study) FY 1997 - planned phase B (definition study)

ACCOMPLISHMENTS AND PLANS

The world's astronomical observatories had a unique opportunity to observe Comet Shoemaker-Levy 9 enter into Jupiter's atmosphere during July 1994. Significant advances were made in our scientific understanding of the structure and chemical

composition of the impacting bodies. Another discovery in 1994 included the first detection of a planetary system around a star other than the Sun. Ribonucleic Acid (RNA) has been evolved in a test tube, performing both catalytic and genetic function, lending credence to the RNA hypothesis for early life. In addition, data from the Magellan mission has shown that the distribution of impact craters indicates the Venusian surface is young -- around 300-500 million years old.

The Planetary Data System published Welcome to the Planets, an interactive CD-ROM featuring a collection of color images of all the major planets and their satellites, along with descriptive narratives (text and voice) and physical data for these bodies. The images were selected from among the best returned by NASA planetary spacecraft. The collection is aimed at K-12 level students, educators, and the interested public.

The framework for participation in European Space Agency's (ESA) Rosetta mission was established in FY 1994, including the development of a joint NASA/CNES design for a comet nucleus lander: an Announcement of Opportunity (AO) for lander instruments is planned for March, 1995. Other mission and technology studies supported in FY 1994 include: ASEPS (Astronomical Study of Extrasolar Planetary Systems): NSTAR (a solar electric propulsion validation and flight test activity); microspacecraft advanced technology development: an outer solar system power study: mission studies of low cost concepts for Mars sample return. asteroid sample return, outer planet probes, and Venus balloon missions.

Preliminary mission studies for the Mars Surveyor Landers were completed. and Phase B activities begun, leading to a flight system Request For Proposals (RFP) and instrument AO in FY 1995. Significant progress was made in defining a low cost Pluto Flyby mission, including the completion of a two year advanced technology insertion program. and the development of options for international cooperation.

With the completion of the Department of Defense's Clementine mission to the Moon and the collection of nearly two million lunar multispectral images, NASA plans support analysis of this rich data set for scientific purposes. In addition, funding will be provided for the scientific analysis of the data set from the Galileo mission encounter with two asteroids as it passed through the asteroid main belt. Approximately 40-50 investigations will be supported at a variety of institutions. Funding will also be provided for the production of multispectral image cube data sets that will support the most sophisticated types of scientific analysis in the future.

Although the annual probability of the Earth being struck by a large asteroid or comet is extremely small, the consequences of such a collision could be catastrophic. Consequently, it appears prudent to asses the nature of the threat and to prepare to deal with it. NASA formed the Near-Earth Objects (NEO) Survey Committee to assist it in developing a plan to detect near Earth objects. The objectives of the NEO Survey are to detect, characterize, and catalogue all comets and asteroids greater than one kilometer in diameter that cross the orbit of the Earth and determine their orbits around the Sun. Efforts will be coordinated with the Department of Defense and space agencies from other countries.

A cooperatively administered NASA and National Science Foundation data analysis and interpretation program will begin with the selection of the investigators to undertake the synergistic Inter-comparison of data sets of the Comet Shoemaker-Levy9/Jupiter collision to advance our scientific understanding in the areas of: the structure and composition of the impacting bodies: the

chemical, physical, and the structure of the Jovian atmosphere and the interior; the interaction of the Jovian magnetosphere with cometary dust and grains; and the physics of entry phenomena.

In order to have a coherent and coordinated program of transferring the exciting and scientifically important new discoveries from solar system exploration, one million dollars is being provided to support scientists to transfer their latest scientific discoveries and vast knowledge to the education community. This program encourages partnership with educational organizations and individuals as well as industry, academia and government to develop products and approaches to transferring information and knowledge obtained through the exploration of the planets to teachers and students at the K-12 level.

BASIS OF FY 1996 FUNDING REQUIREMENT

LAUNCH SERVICES

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996
Med-lite	---	---	13,300
Medium	34,200	56,700	43,500
Large..	86,400	78,100	98,900
To	120.600	134,800	155,700

PROGRAM *GOALS*

Launch Services are a vital element in the achievement of the overall goals of the Space Science program. Expendable Launch Vehicles (ELVs) provide safe. reliable, timely and cost-effective launch services for planetary missions, and possess the unique capability of delivering spacecraft beyond Earth orbit to other points in the solar system and beyond.

STRATEGY FOR ACHIEVING *GOALS*

Payloads may be launched aboard a number of vehicles, each of which supports a discrete performance class. Medium class payloads require launch services capable of delivering up to 11,000 pounds to low Earth orbit. These missions are launched aboard the Delta launch vehicle, which is developed by McDonnell-Douglas (MDAC). These vehicles may be launched either from the Cape Canaveral Air Force Station (CCAFS) or, if a polar orbit is required, from the Vandenburg Air Force Base (VAFB). The Med-Lite is a new class of vehicle which will provide approximately one half the lift capacity of the Delta. Contractor selection for the new Med-Lite is currently underway. Large class payloads requiring the delivery of up to 39,000 pounds to low Earth orbit are launched aboard the Titan IV/Centaur launch vehicle, developed by the Martin-Marietta Corporation (MMC). NASA is procuring the Titan IV/Centaur launch vehicle for Cassini via an existing contract between the United States Air Force (USAF) and MMC. A separate contract for mission unique integration activities is established directly between NASA and MMC.

Funding for mission-unique launch services is now included under the budget request for the benefiting program. Funding support for management oversight of the entire Launch Services program rests with the Launch Vehicles Office (LVO), which is now part of the newly-formed Office of Space Access and Technology (OSAT). The LVO aggregates NASA, NOAA, and international cooperative ELV mission requirements. establishes appropriate acquisition strategies for purchasing firm, fixed priced launch services from the U.S. industry, and imposes the scope and level of technical oversight of the commercial ELV operators' delivery of service that reflects the criticality of the mission and the level of government resources at risk. The administration. procurement, and technical oversight of launch services in the small and medium performance classes is managed by the Goddard Space Flight Center (Pegasus XL, Med-Lite and Delta II) Large class (Titan IV/Centaur) launch services are managed by the Lewis Research

Center (LeRC). KSC is delegated responsibility for technical oversight of vehicle assembly and testing at the launch site by GSFC and LeRC and is responsible for spacecraft processing at the launch site.

MEASURES OF PERFORMANCE

NEAR launch - February 1996	Launch aboard a Delta 11 launch vehicle.
Mars Global Surveyor launch - November 1996	Launch aboard a Delta 11 launch vehicle
Mars Pathfinder launch - December 1996	Launch aboard a Delta 11 launch vehicle
Cassini launch - October 1997	Launch aboard a Titan IV/Centaur launch vehicle

ACCOMPLISHMENTS AND PLANS

Medium class launch services funding provides ongoing support for Delta II launch vehicles for the Near Earth Asteroid Rendezvous, Mars Pathfinder, and the Mars Global Surveyor missions currently scheduled for launch during 1996.

Med-Lite launch services provided in FY 1996 supports initial procurement of two Med-Lite launch vehicles for the Mars Surveyor program in support of the December 1998 launch opportunity. Initial funding is also provided to procure a Med-Lite launch vehicle for the next Discovery mission. Although the mission is not yet selected, launch services funding supports a planned launch in late 1998.

Funds are also provided for a Titan IV/Centaur launch vehicle for Cassini in support of a planned launch in October 1997. The majority of these funds in FY 1994-96 are required for launch vehicle hardware from Martin-Marietta which is being procured for NASA by the United States Air Force (USAF). Funds also support mission integration activities at Martin-Marietta which are funded under a contract directly between NASA and Martin.

Life and Microgravity
Sciences and
Applications

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995	FY 1996	Page Number
		(Thousands of Dollars)		
Life sciences				
Research and analysis	55.100	50.700	50.400	SAT 2-6
Flight program	131.700	90.000	84,000	SAT 2-13
Subtotal	186,800	140.700	134,400	
Microgravity science research				
Research and analysis	18.400	30,400	30,200	SAT 2-20
Flight program	156.600	101,500	109.700	SAT 2-25
Subtotal	175,000	131.900	139,900	
Space shuttle/spacelab payload mission				
Management and Integration	108,700	113.000	85.400	SAT 2-31
Aerospace medicine/occupational health	(2,700)	7,000	7.000	SAT 2-35
Space station payload facilities				SAT 2-38
Life science facilities	24,000	42,900	53,900	
Microgravity facilities	13,000	32,000	65,600	
EXPRESS racks/lab support equipment	____	15,600	17.800	
Subtotal	37,000	90,500	137,300	
To	507.500	483.100	504.000	

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

Distribution of Program Amount by Installation

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Johnson Space Center	130,800	98,300	108,900
Kennedy Space Center	27,900	20,900	19,400
Marshall Space Flight Center	122,000	112,000	125,200
Ames Research Center	66.600	63,500	71,800
Langley Research Center	7,200	800	3,600
Lewis Research Center	74,400	75,900	82,700
Goddard Space Flight Center	500	--	300
Jet Propulsion Laboratory	16,200	2,500	8,000
Headquarters	61,900	109,200	84,100
Total	507,500	483,100	504,000

! OF LIFE AND IT SCIENCES AND APPLICATIONS

PROGRAM GOALS

The NASA Life and Microgravity Sciences and Applications program leads the nation's effortsin space biological, physical and chemical sciences and aerospace medicine, supporting technology development, and applications using the attributes of the space environment to advance knowledge, to improve the quality of life on Earth, and to strengthen the foundations for continuing the exploration and development of space. Major program goals are: (1) understand the role of gravity in biological, physical and chemical systems, and (2) develop and provide technologies and research data essential to design and operate space-based systems, and to maximize the health, well-being and productivity of humans in the exploration and utilization of space.

STRATEGY FOR ACHIEVING GOALS

The Office of Life and Microgravity Sciences and Applications (OLMSA) at NASA Headquarters consists of four divisions: the Life and Biomedical Sciences and Applications Division, the Microgravity Science and Applications Division, the Flight Systems Division, and the Aerospace Medicine and Occupational Health Division. The OLMSA also manages the Space Station Payload Facilities development program.

The program contributes to the creation of new scientific knowledge by studying the effect of the space environment on important biological, chemical, and physical processes. The ground-based research programs support over 500 peer-reviewed Principal Investigators at over 217 universities and colleges over a diverse range of disciplines including human physiology, gravitational biology. materials science, fluids physics, combustion science, and biotechnology.

The flight programs in life sciences and microgravity develop experiments to fly on orbiting spacecraft such as the Spacelab modules, Space Shuttle pallet payloads, Space Shuttle middecks, the Mir Space Station and the International Space Station Alpha (ISSA). The Flight System Division provides Headquarters program management for the mission planning and integration for all of these experiments as well as for additional attached Space Shuttle payloads developed by other NASA organizations.

As NASA moves into the Space Station era, there will be a major transition from the current on-orbit experimentation program to the international Space Station. The core of the Space Station program will be six major research facilities: the Gravitational Biology Facility (GBF), the Centrifuge Facility (CF), the Human Research Facility (HRF), the Space Station Furnace Facility (SSFF), the Biotechnology Facility (BTF) (which includes the Protein Crystal Growth experiment) and the Fluids/Combustion Facility (FCF).

The Life Sciences Research and Analysis program supports ground-based research and definition studies in six major areas: (1) Space Physiology and Countermeasures, (2) Space Human Factors Engineering, (3) Environmental Health, (4) Space Radiation Health, (5) Advanced Life Support, and (6) Space Biology. The Research and Analysis program also includes data archiving, laboratories. NASA Specialized Centers of Research and Training (NSCORTS), and joint activities with the National Institutes of Health (NIH) and the National Science Foundation (NSF). Ground-based research relies on unique gravitational and simulation facilities such as centrifuges and parabolic aircraft.

The Life Sciences Flight program, consists of the Space Shuttle/Spacelab flight experiments program, the NASA/MIR Research Program (NMRP), the Space Station Utilization program and other international cooperative efforts. The flight experiments program selects. defines, develops and conducts in-space medical and biological research, and tests advanced life support and extravehicular technologies. The broad variety of multi-user research facilities it develops is designed to support the life sciences community's needs of the future.

The Microgravity Science Research and Analysis program supports ground-based research and definition studies for flight experiment candidates in five primary areas: (1) Biotechnology. (2) Combustion Science, (3) Fluid Physics, (4) Materials Science. and (5) Gravitational Physics. Ground-based research includes laboratories, drop-tubes. drop towers and parabolic aircraft.

The Microgravity Science Flight program, consisting of a flight experiments program. the NMRP and the Space Station Utilization program, provides a wide range of experimental capabilities. The flight program supports a broad variety of hardware experiments including, both unique one-of-a kind scientific experiments as well as multi-user research facilities, which will serve as the cornerstones of microgravity science and applications research in the future. Experiments will be principally flown in the Space Shuttle, Spacelab, sounding rockets and/or other commercially-developed spacecraft.

The Space Shuttle/Spacelab Mission Management and Integration program performs the mission planning, integration and execution of all NASA/Spacelab, the NMRP and attached Space Shuttle payloads. The program includes integration of the scientific payloads into the various carriers, payload specialist training and system management and engineering development of flight equipment and software.

The Aerospace Medicine and Occupational Health program is responsible for the maintenance of health, medical safety and productivity of our astronauts in space and for protecting and promoting the health and safety of all NASA employees. The program also includes tele-medicine and global health applications projects. This program also includes clinical medicine responsibilities that have been transferred from the Life Sciences Research and Analysis program.

NASA is continuing to develop and broaden its cooperative research programs with Russia. The keystone of *those* efforts is the Phase I NASA/MIR Research Program that includes seven missions to the Mir Space Station over the next three years. This program will provide NASA with opportunities to conduct long-duration, on-orbit research in life sciences and microgravity sciences and space medicine.

The continued development of the Space Station Payload Facilities will remain one of the highest priorities of NASA . In addition to the six major facilities, NASA will develop Laboratory Support Equipment and Expedite the Processing of Experiments to Space Station (EXPRESS) racks for the station, NASA has completed a major redesign activity of the Centrifuge Facility that will result in a simplified but highly capable facility that will be delivered to the Space Station three years earlier than the prior design and at a lower cost.

BASIS OF FY 1996 FUNDING REQUIREMENT

LIFE SCIENCES RESEARCH AND ANALYSIS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Life sciences research and analysis.....	55,100	50.700	50,400

PROGRAM GOALS

The Life Sciences Research and Analysis program sponsors basic and applied research in biomedicine, biology, environmental science, and related technologies in support of the Agency's strategic goals. The program goals are: (1) to effectively use microgravity and the other characteristics of the space environment to enhance our understanding of fundamental biological processes: (2) to develop the scientific and technological foundations for a safe, productive human presence in space for extended periods and in preparation for exploration: and (3) to apply this knowledge and technology to improve our nation's competitiveness, education. and the quality of life on Earth.

STRATEGY FOR ACHIEVING GOALS

Life Sciences Research and Analysis program supports applied research as well as basic research. Its basic research activities use the unique weightless environment of space as a tool to learn about basic structures and functions of humans, other animals, and plants. Its applied research activities enable the development of procedures or countermeasures to prevent the undesirable effects of space flight on humans. Life Sciences Research and Analysis pursues its goals through ground-based research programs and projects at universities, NASA Centers and other Federal agencies including NIH. It also finances specialized support facilities and technologies.

The Life Sciences Research and Analysis program supports ground-based research in the following areas: (1) gravitational research. (2) environmental and human factors research, and (3) advanced life support systems research. Gravitational research in the biological, biomedical, environmental, and psychosocial sciences is composed of the space biology and the space physiology and countermeasures program areas. Environmental and human factors research subdivides into the environmental health program area, space radiation health. and the space human factors area. The advanced life support program consists of advanced life support and the advanced extravehicular activity systems areas.

The Research and Analysis program also sponsors three additional specialized activities and services. The Advanced Technology Development and Data Analysis activities respond to the defined needs of the space life sciences ground-based and flight programs. The Research and Analysis program's Education and Outreach activity informs the professional community about space life sciences activities, encourages students to consider careers in space life sciences, and sponsors development programs aimed at those already engaged in life sciences research careers.

All sponsored research is peer-reviewed, consistent with revised and updated peer review policies implemented during FY 1994. The program's peer review program is administered from Headquarters, and proposals submitted by NASA Field Center researchers are subjected to the same rigorous review standards as those of extramural researchers. The Life and Biomedical Sciences and Applications program's procedures enable peer reviews of selected proposals to be performed under cooperative arrangements with the National Institutes of Health (NIH).

The Space Biology program seeks to improve understanding of the role of gravity on biological processes by using a variety of gravitational environments (hypergravity, simulated hypogravity. and microgravity) as research tools or by determining the combined effects of gravity and other environmental factors on biological systems. The program emphasizes research in cell and molecular biology, developmental biology. plant biology. and systems biology. Its research includes plants or animals as subjects. as well as cell or tissue cultures.

The Space Physiology and Countermeasures program conducts research that seeks to characterize and determine the mechanisms of the physiological changes in weightlessness, including those that threaten to limit the duration of human space missions. It also develops integrated prophylaxis or rehabilitation methods that allow humans to live and work in microgravity. minimize the risk of returning to Earth's gravity, and optimize crew safety, well-being, and performance.

The Environmental Health program seeks to understand the effects of spacecraft environments on humans, animals, and other organisms. It attempts to specify, measure, and control these environments. and it develops standards and countermeasures, where necessary, to optimize crew health, safety, and productivity. Research within the Environmental Health program includes four interrelated disciplines. each dealing with a specific aspect of the spacecraft environment: barophysiology, microbiology, toxicology, and water quality. The program develops monitoring techniques, procedures, and standards for extended Space Shuttle missions and the international Space Station.

The Space Radiation Health program conducts research needed to establish the scientific basis for the radiation protection of humans engaged In the development and exploration of space, with particular emphasis on the establishment of a firm knowledge base to support possible future planetary exploration, and to predict the probabilities of deleterious health effects due to radiation exposure during human space activities. The emphasis of this program is on mechanistic studies with the potential to enable extrapolation of scientific research results to human beings in space.

The Space Human Factors program integrates knowledge about human capabilities and system engineering methodologies. It develops new processes and procedures to enhance crew training and performance and to improve complex automated systems designs. It also studies the psycho social issues of humans in isolated environments. The program achieves its objectives. in part, by sponsoring or supporting Earth-based analog studies in extreme and isolated environments.

The Advanced Life Support program develops advanced regenerative life support systems by combining biological. physical, and chemical processes capable of producing and recycling the food. air, and water needed to support long-term human missions in space in a safe and reliable manner. Its projects and activities apply engineering sciences to the design of technologies that

support and control physical-chemical and bioregenerative closed loop systems for clean air and potable water. The program applies knowledge from the life sciences to grow, harvest, and process crop plants for flight crew consumption.

The Advanced Extravehicular Activity (EVA) Systems program develops the technologies necessary to perform the EVAs productively. safely. and efficiently during future long-duration missions. The EVA systems are defined as the operational hardware and operational procedures that allow safe, efficient, and productive crew activities in the proximity of a planetary habitat, a spacecraft, or an orbiting station. The EVA hardware includes space suits. portable life support systems, and items such as foot restraints, tools, work stations, and interfaces. These items, along with operational procedures and protocols, are candidates for advanced EVA systems technology development.

The Advanced Technology Development (ATD) program sponsors multidisciplinary technology development activities that enhance the capability. reliability or quality of Life Sciences flight hardware. The program solves technical problems that currently limit science return from existing flight equipment. It enables new types of scientific investigations in space: promotes technology transfer of Life Sciences technology to industry: and establishes partnerships with industry, universities, and other agencies.

The Data Analysis program stimulates the thorough analysis of data gathered during space flight and its Earth analogs. This program sponsors extended analysis of data collected during space flight. It supports life sciences data base and archive development, and promotes the development of special data analysis techniques, which promise to strengthen the analysis of data from space flight, such as mathematical modeling, computer simulation, artificial intelligence or statistical methods.

The Life Sciences Research and Analysis program manages its projects, activities, and tasks from Headquarters and from the following NASA Centers: the Ames Research Center (ARC). the Johnson Space Center (JSC), and the Kennedy Space Center (KSC). Following the program's adoption of revised peer review procedures during FY 1994, NASA returned the responsibility for extramural grants management to Headquarters. Beginning in FY 1995. all the program's peer-reviewed research and technology awards to extramural researchers will be managed and administered from Headquarters. Center researchers will continue to perform intramural peer-reviewed research and technology projects and tasks, as well as applied research and technology tasks. The Centers also maintain various specialized research facilities that support the investigations of extramural and intramural researchers alike.

The American Institute of Biological Sciences will assist Headquarters in administering the program's peer review processes until its contract with NASA expires in mid-FY 1995. NASA will choose a successor contract in 1995 which will consolidate peer review for all peer-reviewed research and technology programs. The ARC and the JSC receive support from the Bionetics Corporation and Krug Life Sciences, respectively. The Dynamac Corporation was recently selected to support the KSC's life sciences research and technology programs during the first quarter of FY 1995, with subcontracted support from Bionetics Corporation.

Life Sciences Research and Analysis program resources support more than $5.0 million annually of collaborative activities with the NIH. Life Sciences resources dedicated to joint NASA/NIH collaboration are likely to increase in future years, stimulated both by past collaborative efforts and by the recommendations of the NASA/NIH Interagency Advisory Committee. Collaborative efforts between NASA and the NIH researchers are proceeding on a number of fronts. The two agencies collaborate on such things as the

Human Brain project, a collaborative effort focusing on neural science and informatics research. NASA and the NIH will continue to provide mutual support to a NASA/NIH Specialized Center of Research and Technology (NSCORT) for Vestibular Research at Northwestern Medical Center in Chicago. A sampling of other collaborative research and technology projects which NASA Life Sciences has underway with the NIH include several projects in cancer research, including a technology development task which aims to develop advanced digital mammography techniques. The agencies are examining similarities between space flight and the aging process. They are working together on neurological and behavioral sciences research, developmental physiology and human development research, and cardiovascular, pulmonary, and hematologic systems research. The two agencies are supporting several activities designed to enhance the electronic information services available to life sciences researchers. For example, SPACELINE. an on-line bibliographic database of space life sciences, should become available for use during FY 1995.

The program participates with a variety of other organizations whose research interests intersect those of the Life Sciences Research and Analysis program. Such organizations include the American Society for Gravitational and Space Biology and the American College of Sports Medicine. The program also reaches out to groups whose members are underrepresented in the life sciences research community, such as the Alaska Native Associations.

MEASURES OF PERFORMANCE

Release Life Sciences NASA Research Announcement 1st Qtr FY 1995 1st Qtr FY 1996	Ensure a steady source of peer-reviewed research and development tasks.
Complete 50 Life Sciences R&A tasks FY 1994/FY 1995/FY 1996	Ensure a steady flow of life sciences research benefits.
Complete 5-year performance period for NSCORTs/recompete 4th Qtr 1995	Conclude NSCORTs in Gravitational Biology, Bioregenerative Life Support, and Environmental Health.

IPLISHMENTS AND PLANS

FY 1994 was a period of significant activity for the Life Sciences Research and Analysis program. The program's activities ranged from continued efforts to improve the quality of the science and peer review process to joint participation or sponsorship of science conferences and workshops with NIH, and successful demonstration of a number of promising new technologies.

Collaboration or joint sponsorship of workshops and related activities during FY 1994 included a jointly sponsored workshop with the NIH's National Heart. Lung. and Blood Institute, where researchers gathered to discuss recent research results in cardiovascular, pulmonary, and blood functions. Additional opportunities for life sciences researchers to present their research findings occurred through participation with such organizations as the American Society for Gravitational and Space Biology. and the American College of Sports Medicine. Successful collaboration with the National Science Foundation resulted in the

establishment of the Life Sciences Research and Analysis program's ninth NSCORT. The new plant biology NSCORT was established at Ohio State University. It is composed of nine projects selected from 35 research proposals.

The Advanced EVA System program is also co-sponsoring a program with the multiple sclerosis community that will continue NASA's efforts into the development of micro-climate technologies. The goals of this project are to help establish cooling protocols for the multiple sclerosis patients and to coordinate a nationwide clinical study that will determine the medical efficacy of cooling for these patients.

NASA, the Alaska Native Associations, the University of Alaska, and industry joined together in FY 1994 to plan for the development of appropriate systems, derived from NASA life support technologies, for waste handling and the purification of water for hygiene and potable uses appropriate to the unique conditions of rural Alaska.

The first test of a new closed loop Integrated Air Revitalization System was conducted at the Johnson Space Center (JSC). The test system consisted of a four-bed molecular sieve subsystem, a Sabatier carbon dioxide reduction subsystem, a solid polymer electrolyte oxygen generation subsystem, and the associated hardware required to integrate the subsystems. The test successfully demonstrated automated operation of an integrated life support system with capabilities beyond those presently available.

A program was initiated during FY 1994 to develop advanced technology biosensors which will address NASA's future physiological monitoring needs. These sensors have already generated considerable interest in the medical community and cooperative projects have been initiated with both the University of California, San Francisco medical center to use these sensors for monitoring fetal development and Cedars-Sinai for monitoring blood parameters.

During FY 1995, the Life Sciences Research and Analysis program will complete the first competitive renewal of three NSCORTs. The Centers that will be selected following recompetition are in the areas of Gravitational Biology, Environmental Health, and Bioregenerative Life Support.

FY 1995 program planning and outreach activities will include three major workshops. The Neural plasticity workshop, to be co-sponsored with the Johns Hopkins University, will take place in February 1995. It will summarize recent research findings in how neural structure and function can be altered by environmental and other stimuli. It will point towards new research directions and potential applications in space and Earth. A symposium on NASA and the Decade of the Brain, co-sponsored by the National Foundation for Brain Research, will be held in June 1995. This symposium will survey the recent advances in the neurosciences and discuss how NASA can further the tremendous advances in the brain and behavioral sciences for the benefit of people on Earth and in space. Finally, a workshop on environmental health will be conducted in the summer of 1995 in conjunction with the National Institute of Environmental Health Sciences (NIEHS). This workshop will bring together leading investigators supported by the National Institutes of Health (NIH) and NASA, and it will result in recommendations on future joint initiatives and programs for NASA and the NIEHS.

The Life Sciences Research and Analysis program in FY 1995 will provide extramural investigators with increased access to NASA-unique facilities supported by NASA and other Federal agencies. Specifically, the program will increase access to the

Biocomputation Center, the Vestibular Research Facility and other radial acceleration facilities at the Ames Research Center, and the KC-135 and other biomedical facilities at the JSC. Additionally. the program will initiate a study to evaluate and plan for advanced space suit systems necessary to reduce the risk of decompression sickness, and the program will begin developing more capable systems for long-duration and planetary missions.

During FY 1996. the Space Biology program will focus on advancing fundamental knowledge in the biological sciences using the tool of gravity and microgravity. The program will apply that knowledge to support NASA's goal of enabling human exploration of space and improving the quality of life on Earth through advances in medicine, agriculture, biotechnology, and environmental management.

The Cell Biology program will attempt to answer questions on how gravitational information is transduced: how cells respond to both acute and long-term variations in gravity: and how gravity affects the composition, size, shape. and function of cells. The Developmental Biology program will study the influence of gravity and microgravity on animal growth, development, reproduction, genetic integrity. life span, senescence, and subsequent generations of animals. The Plant Biology program will conduct research to understand how plants perceive, transduce, and respond to a gravitational force. It will elucidate the role of hypergravity and microgravity in developmental and reproductive processes in plants, and it will seek to understand the role of hypergravity and microgravity in the metabolism and transport processes in plants. Finally, the Systems Biology program will study the ways in which organisms sense and integrate gravitational information, and how organisms facilitate orientation and locomotion. The Systems Biology program will also test mechanisms of gravitational adaptation, and it will support research which attempts to determine the gravitational influence on genetic expression relating to physiologic function, such as rhythms. stature, locomotion, etc.

The Space Physiology and Countermeasures program will continue to redirect its ground-based research emphases during FY 1996 from studies related to acute problems of short-term space flight to problems associated with extended stays in space. especially stays of 90 days to 180 days (i.e., up to the mission durations of the international Space Station). The Space Physiology and Countermeasures program will fund both basic and applied research in studies of the applied effects of hypogravity and hypergravity. Studies may include human subjects and other animal models. The program will seek new techniques for the non-invasive, inflight measurement of the variables that characterize all systems. It will also address the development of an optimal exercise protocol for space flight that will provide an effective, comprehensive countermeasure for the various physiological and psychological systems, including cardiovascular, musculoskeletal, neuromuscular function, fluid and electrolyte balance, and performance, while minimizing demands on crew time.

The Environmental Health program in FY 1996 will conduct research that is relevant to the establishment of space flight environmental standards for human health and performance. It will define physiological norms for atmospheric gases, identify toxicants and describe microbial populations (including their numbers, pathogenicity, or products). The program will emphasize investigations of optimal nitrogen washout protocols and it will use ground-based studies to anticipate the effects of closed systems in space.

The Radiation Health program in FY 1996 will support ground-based experimental radiobiology studies using proton and high-energy heavy ion beams. The highest priority will be assigned to studies leading to significant advances in understanding the mechanisms of radiation-caused carcinogenesis and in the reliability of interspecies extrapolation of radiobiological effects (in particular. extrapolation to humans).

During FY 1996. the primary focus of the Space Human Factors program will shift from knowledge acquisition to knowledge application. This shift will extend human factors support to operational areas and it will emphasize the improvement of processes and products. The program will emphasize the identification and development of projects with clearly defined technology or product deliverables in the following five areas: Advanced Displays and Controls Development: Human-Machine Function Allocation: Interactions Among Intelligent Agents: Intravehicular Activity: and Analog Studies.

The primary emphases of the Advanced Life Support program during FY 1996 will be in the areas of solid waste processing, food processing and system studies. Programmatic relevance will be evaluated relative to these emphases. Life Sciences Research and Analysis will also support additional system studies and the further development of the EVA system requirements. Proposals in the following areas will be considered: Mission Requirements Definition: EVA Human Factors: Physiological and Medical Requirements: EVA Task Requirements: Systems Studies: and EVA Mission Operations.

The primary emphasis of the Advanced Technology Development program during FY 1996 will be on environmental sensors. The program will also begin development of advanced implantable biotelemetry systems, advanced data handling, and advanced lighting systems. Also of interest to the Advanced Technology Development program will be the development of new or improved methods for expanding the comprehensive database of chemical contaminants present in waste water and processed water produced by terrestrial-based. prototype water processor testing and development.

Also during FY 1996, the Data Analysis program will concentrate on extended data analysis. Secondary emphasis will be on the area of special data analysis techniques. Because of resource constraints, the program will support projects related to data base and archive development only in cases where exceptional benefits to the scientific community or to NASA's life sciences data archive project will result.

NASA plans to maintain the number of Life Sciences ground-based Principal Investigators in FY 1996 at approximately 220. The number of research proposals received is expected to reach 910 in FY 1996 and the number of major journal publications is planned to be at the 500 level for that same year.

BASIS OF FY 1996 FUNDING REQUIREMENT

LIFE SCIENCES FLIGHT PROGRAM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Flight experiments program	100,200	72,900	59,000
NASA/MIR research program	31,500	16,600	20,800
Space station utilization program	--	500	4,200
Total	131,700	90,000	84,000

PROGRAM GOALS

The Life Sciences flight experiments program systematically manages and supports investigations with living systems which require access to the unique characteristics of low-Earth orbit. The program secures timely space flight opportunities for the space investigations it sponsors. The program uses microgravity and the other characteristics of the space environment to enhance understanding of fundamental biological processes. In addition, the program's flight research and technology develops the scientific and technological foundations for a safe, productive human presence in space for extended periods.

STRATEGY FOR ACHIEVING GOALS

The Life Sciences flight experiments program strives to endorse and develop the highest-quality research and technology. The program solicits a steady stream of new research and technology investigations, manages and supports them during pre-flight definition, development, and through post-flight. The program relies upon peer reviews to determine which science research and technology to endorse. Its peer review process in recent years has become a cooperative enterprise with the National Institutes of Health (NIH). Cooperative enterprises such as those with the NIH and other external partners ensures that only the highest ranked, peer-reviewed research and technology projects receive flight opportunities.

The Life Sciences flight program provides a balanced and robust series of flight opportunities. The program delivers human-assisted or human-subject flight opportunities aboard the Space Shuttle. The program also sponsors research opportunities aboard unmanned vehicles. The program uses Spacelabs that fly in the Space Shuttle cargo bay as well as Space Shuttle small payloads. As the nation approaches the era of the international Space Station, the Life Sciences flight program will begin taking advantage of longer-duration flight opportunities aboard the Russian Mir space station. NASA/MIR Research program investigations will enable the Life Sciences flight program to conduct research, develop technologies, and help mitigate the risks of long-duration space flight. In the Space Station era, crews will remain on orbit for as long as 180 days at a time; the Life Sciences flight program will provide enabling technologies to take maximum advantage of this long-duration opportunity.

To reinforce its science objectives and to ensure safe human presence in space, the Life Sciences flight program develops and demonstrates applied technologies. Successful application, for example, of the advanced life support technologies which the Life Sciences flight program develops will enable crews engaged in long-duration flights to recycle food, air. and water more effectively and economically. It will enable crews to grow, harvest, and process crop plants for their own consumption. The Life Sciences flight program's applied technologies programs will enable the development of advanced facilities and other resources for use aboard the Space Station. The Life Sciences flight program also develops technologies, experiments, and protocols which promise to minimize risks to crew health.

The Life Sciences flight program's Spacelab flight opportunities develop and support investigations in the areas of biology, physiology, environmental, psychosocial, and neurological sciences. Flight program funding enables necessary pre-flight planning, development, and support for selected investigations. Program resources provide for post-flight services and appropriate data analysis and distribution, including the development of specialized databases and archiving services to ensure that flight research findings and results are widely available to the research community.

Spacelab opportunities for Life Sciences (SLS) become available about every two-three years. The next scheduled life sciences Spacelab flight, in the third quarter of 1996, is the Life and Microgravity Spacelab mission (LMS); the last scheduled life sciences Spacelab mission is Neurolab, scheduled for the second quarter of FY 1998. One of the important benefits of the LMS mission is that it will provide the flight opportunity for numerous investigations which had been scheduled to fly on the SLS-3, which was canceled. The Neurolab mission will conduct basic research in behavior, communication. sensory disorders, brain development. learning and memory, and rehabilitation and restoration of function.

The Life Sciences flight program also relies upon Space Shuttle small payload opportunities to supplement those afforded by periodic Spacelabs. The objectives of small payload flights are to provide scientists and researchers with opportunities to fly their research quickly and economically, via the Space Shuttle middeck. The science conducted may be in plant biology, developmental biology. cellular research, human factors, and performance disciplines. Most of the research uses existing flight hardware. Small payload opportunities demonstrate hardware or develop research techniques in advance of upcoming Spacelab, NASA/MIR Research Program (NMRP), or Space Station missions. NASA anticipates that, once the Space Station becomes operational. small payload-class investigations will migrate to the Space Station's EXPRESS rack program.

The Life Science flight program will conduct long-duration science aboard the Russian Mir space station, and it will conduct science investigations on the Space Shuttle rendezvous missions to Mir. NASA plans seven Space Shuttle missions to Mir, with the last scheduled for the last quarter of FY 1997. Life Sciences will also support research investigations in environmental monitoring and countermeasures aboard NASA/Mir. These investigations will emphasize musculoskeletal, cardiovascular, regulatory physiology, and neuroscience research, along with plant biology and other fundamental biology research.

Program resources will enable life sciences researchers to use the Biorack facility in the NMRP. The Biorack facility. previously developed by the European Space Agency (ESA), will fly on three of the seven scheduled Space Shuttle flights to the Mir. The Biorack will be accommodated inside the pressurized Commercial Middeck Accommodations Module (CMAM), owned by Spacehab.

Inc. Biorack researchers will investigate cellular functions and developmental processes in plant and animal tissues. In particular, Biorack investigators will evaluate how cells respond to gravitational changes.

NASA will also use Mir to perform flight experiments in environmental control and advanced life support, in space station crew health care systems, and in extravehicular activity (EVA). These investigations will reduce technical, schedule, and cost risks associated with the development and operation of the Space Station.

In cooperation with the Russian Space Agency (RSA), the Life Sciences flight program conducts primate biological experiments on unmanned biosatellites. The unmanned Bion series of biosatellites flies biological and radiation measurement experiments in near-Earth orbit. Since 1973, the Republic of Russia has launched ten biosatellites: the U.S. has participated in the last eight missions. The major objectives of the Bion investigations are to study the biological effects of microgravity and radiation on living systems: to evaluate living systems' adaptation to microgravity and other characteristics of space: and to evaluate the fundamental characteristics of living systems, using gravity as a variable. Bion primate missions last up to fourteen days.

The participating Centers in life sciences research include the Johnson Space Center (JSC), which leads in the development and support of life sciences investigations in the areas of space physiology and environmental and human factors, and advanced life support. The Ames Research Center (ARC) leads the program's development of space biology research investigations, advanced life support, and it plays the primary life sciences role in the development of primate investigations scheduled for launch aboard the Bion biosatellite missions. Both NASA Centers participate on Spacelabs, small payloads, NMRP, and the Space Station. The Kennedy Space Center (KSC) manages life sciences payload integration. provides pre- and post-flight support, manages advanced life support facilities and demonstrations, and it manages small payload investigations.

NASA's Centers obtain services from a variety of support contractors to fulfill their obligations to life sciences programs and disciplines, although Agency effortsto recompete and consolidate technical and support contracts are altering the mix of firms represented at the Centers. Martin Marietta supports hardware and payload development tasks at JSC and at ARC. Lockheed Engineering and Sciences Corporation also supports payload development at ARC. KSC recently selected Dynamac, Inc. for a new seven-year contract for the support of payload processing and life sciences facilities support. The previous contractor, the Bionetics Corporation, will support the KSC in a subcontract role. The ARC also has plans to consolidate its contractor support: a new consolidated support contract at that Center will be awarded during FY 1995.

The Life Sciences Flight program seeks opportunities to enhance its science research and technology development activities by promoting cooperative ventures with external entities and researchers. Mutually beneficial cooperative agreements lead to better science, better dissemination of science results, or more economical ways of doing business.

For example, on the LMS mission the Department of Defense will fly a new cell culturing system, and ESA will fly the Torque Velocity Dynamometer for the first time to conduct musculoskeletal and combined musculoskeletal and neurophysiological experiments. On the Neurolab mission, twelve of the thirty-four investigators selected for definition are international; the international space agencies of Canada, Europe, France, Germany. and Japan are participating. Domestic Neurolab participation

will come from NIH, which is playing a leading role in Neurolab science management and development. Other domestic Neurolab participants include the National Science Foundation (NSF)and the Office of Naval Research.

Aside from the program's Spacelab missions, international and domestic partners play vital roles in the Life Sciences Flight program's small payloads program. The French, Russian, German, and Canadian Space Agencies represent 10% of the small payloads principal investigator population. The small payloads program uses flight hardware provided by other Federal Agencies, such as the Walter Reed Army Institute for Research, along with hardware from Canada, Germany. and others.

MEASURES OF PERFORMANCE

The first phase of the NASA/Mir Research Program (NMRP)launches to Mir - 3rd Qtr FY 1995	During an American astronaut's ninety-day stay aboard the Mir spacecraft, NASA Life Sciences will conduct up to twenty-two musculoskeletal, cardiovascular, regulatory physiology. and neuroscience investigations.
Second phase of NMRP begins - 1st Qtr FY 1996	NMRP will conduct long-duration science aboard the Mir space station. emphasizing musculoskeletal, cardiovascular, regulatory, physiology, and neuroscience research, along with plant biology and other fundamental biology research. NASA Life Sciences will also take advantage of this program to develop new technologies, enhance capabilities for on-orbit environmental monitoring, and expand basic knowledge of the effects of EVA on humans.
Spacehab, Inc.'s Commercial Middeck Augmentation Module, outfitted with the ESA's Biorack and a suite of life sciences experiments, will fly to Mir - 2nd Qtr FY 1996 4th Qtr FY 1996	NASA Life Sciences research on Biorack will investigate cellular functions and developmental processes in plant and animal tissues.
The Life and Microgravity Sciences (LMS) Spacelab mission flies on STS-78 - 3rd Qtr FY 1996	The LMS flight will support the non-Rhesus science which had been scheduled to fly on the SLS-3 mission. The mission will support musculoskeletal and behavior and performance investigations and build on the research results of the successful SLS-1 and SLS-2 missions.
The U.S. will share 50% of the science from the Bion 11 mission - 3rd - 4th Qtr 1996	Bion 11 will accommodate the Rhesus investigations which had been scheduled to fly on SLS-3. The Bion 11 will conduct muscle physiology and immunology science investigations, along with bone and regulatory physiology investigations.

Multiple life sciences small payloads will fly on shuttle flights -	Twenty-eight NASA Life Sciences small payload investigations will conduct research in musculoskeletal physiology. plant biology, and developmental biology. The Life Sciences small payload program is a critical component in NASA Life Sciences collaborative research with the National Institutes of Health.
FY 1995	
FY 1996	

ACCOMPLISHMENTS AND PLANS

Flight Experiments Program

The Life Sciences Flight program payloads were carried on the International Microgravity Laboratory (IML-2) Spacelab mission, which flew in July 1994. Eighty-two experiments were flown on IML-2, of which forty-two were jointly sponsored by NASA and NASA's international partners. The Life Sciences program directly supported four peer-reviewed IML-2 investigations. along with thirteen Detailed Supplementary Objectives. Program resources will fund data analysis during FY 1995. and researchers will begin publishing their flight results during FY 1996.

The Extravehicular Activities (EVA) Systems program will initiate a study during FY 1995 that will identify technologies and prepare a proposed development plan for a next-generation EVA system. The major objectives of the initiative will be to increase the productivity of EVA systems, to help reduce overall EVA hours on Space Station, and to reduce EVA system maintenance and logistics costs.

During FY 1995, the program will proceed with plans to fly the Life and Microgravity Spacelab (LMS) mission. Payload definition and development will proceed with all scheduled investigations. including those which have been remanifested on LMS from the canceled SLS-3 flight. In addition. a gas analyzer and body mass measurement device will fly on LMS. FY 1995 and FY 1996 resources will upgrade previous versions of these devices, and the pulmonary science they support will build on the science sponsored on SLS-1, which provided the first detailed studies of the lung under resting conditions.

A total of 174 research proposals were submitted during FY 1994 in response to the July 1993 Announcement of Opportunity for Neurolab. The National Institutes of Health (NIH)'s Division of Research Grants conducted the peer reviews of all 174 international and domestic research proposals. Thirty-four of the highest ranking proposals were selected for definition. Eight investigator teams, two of which are being led by the NIH science managers, will use FY 1995 resources to complete the research definition phase. During the third quarter of FY 1995, the NIH will conduct an interim review of the thirty-four investigators selected for definition, and NASA will then select the researchers for the Neurolab flight. NASA will use FY 1996 resources to support the investigators it selects for flight, and it will develop the hardware its researchers need. Also during 1995 and 1996. the NIH will provide ground-based support to some of the U.S. Neurolab investigators.

FY 1995 and FY 1996 resources will support the 48 investigators participating in the life sciences small payloads program. The NIH provides additional support to many of these investigators. The typical small payloads researcher participates for three years, following selection for flight (two years of research prior to flight. and another to analyze the resulting flight data). During FY 1995.

life sciences will fly twenty-eight small payload investigators. The twenty-seven will conduct research in musculoskeletal physiology, in plant biology, and in developmental biology. During FY 1996, the Life Sciences Flight program will fund the NIH-Cells 5 series with two investigators and the NIH-Rodent 3 series, which is a verification payload for Neurolab. It will fly the Aquatic Research Facility. belonging to the Canadian Space Agency and will fly a number of other human performance and plant biology experiments.

NASA plans to maintain the number of Life Sciences flight principal Investigators (PI's) in FY 1996 at 171. Twenty-two of the 171 in FY 1996 will be involved with the Space Station. Forty-five major flight investigations and 11 small payload investigation are planned to be flown in FY 1996.

NASA/MIR Research Program

FY 1995 funding will support the development and delivery to Russia of flight hardware for manifesting on two Progress resupply vehicles and a Spektr science module. These will dock with the Mir prior to the end of the third quarter of FY 1995. An American astronaut will fly to the Mir in the spring of 1995 for a ninety-day stay: during the stay, NASA will sponsor up to twenty-two musculoskeletal, cardiovascular, regulatory physiology, and neuroscience investigations.

Also in FY 1995, Space Shuttle-71 and Space Shuttle-74 will fly to the Mir, marking the end of Space Station Phase IA and the beginning of Phase IB, respectively. A total of 105 research proposals have been submitted in response to a life sciences Announcement of Opportunity for NMRP. NASA has selected fifty-three proposals for definition. and anticipates that it will select the NMRP investigations for flight early during the second quarter of FY 1995.

SpaceHab, Inc.'s CMAM module. outfitted with the ESA's Biorack and a suite of life sciences experiments, will fly to Mir for the first time on Space Shuttle-76 midway through FY 1996. Life Sciences released a NASA Research Announcement in early FY 1995 to solicit Mir/Biorack research investigations. An international panel, including the U.S. will conduct peer reviews of the Biorack proposals late in FY 1995. Life sciences FY 1995 resources, including the U.S., will also support the outfitting of the Priroda module for a November 1995 flight to Mir. The experiment hardware it contains, along with that delivered earlier in 1995, will be used by NASA astronauts throughout the remainder of the NASA/Mir program.

In support of the Space Station program and to take maximum advantage of the NASA/Mir opportunity, life sciences experimenters will use Space Shuttle flights to Mir to develop new technologies, enhance capabilities for on-orbit environmental monitoring, and expand basic knowledge of the effects of EVA on humans. In the life support area, NASA will adapt urine processing and atmospheric revitalization hardware designs for use as flight experiments. In-house and off-the-shelf designs are being pursued for Crew Health Care System experiments in water and air quality monitoring, and crew restraints during medical procedures. NASA is also developing a new technology for measuring crew susceptibility to the bends during the EVA. Four of these environmental systems, life support, and technology development experiments will be launched in FY 1996, with remaining experiments scheduled for the FY 1997 phase of the NMRP.

Bion Program

During FY 1995 the Life Sciences flight program will develop flight hardware and supporting equipment necessary to conduct experiments on two Rhesus subjects on the Bion-11 biosatellite mission. The Bion-11 launch window will cover the period August 1 through November 15, 1996. This mission will fly the primate experiments from the canceled SLS-3 mission. It will accommodate muscle physiology and immunology science investigations, along with bone and regulatory investigations. The 1995 resources will support 50% of the primate science and resulting data analysis. During FY 1996, NASA may exercise a contract option for a Bion-12 mission. The Bion-12 mission would fly during the summer or fall of 1998 and complete the SLS-3 primate studies.

Space Station Utilization Program

FY 1995 resources for Space Station science development and utilization will allow initiation of a number of activities during the year and accelerate them during FY 1996. Program resources will support the further development of relationships with the research community that will use the Space Station facilities. The program will resolve environmental questions that may affect the research program and will evaluate system upgrade alternatives. A main thrust of Life Sciences Space Station activities during the period ahead will be to support researchers who will use chronic centrifugation and who have in experience in the microgravity environment, in order to understand cellular and systemic gravitational responses and adaptation. Investment in this community of researchers should result in more mature and sophisticated experiments on the Space Station for the Gravitational Biology and Centrifuge Facilities. The program will work during the period to set firmer requirements for the Space Station atmospheric carbon dioxide levels, and will apply its findings to the Space Station life support system enhancements.

BASIS OF FY 1996 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE :H AND ANALYSIS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Research and analysis	18.400	30.400	30,200

PROGRAM GOALS

The Microgravity Science Research and Analysis program is designed to establish the intellectual underpinning of the flight program. In order to do this, a multidisciplined, research program has been established in the areas of biotechnology, combustion, fluid physics, materials science and other special topics in physics such as critical point phenomena at low temperatures, and gravitational physics. These ground-based experiments, coupled with a set of experiments selected for flight, comprise a compelling and coherent strategy for utilization of the space environment to obtain understanding of basic physical phenomena and processes, quantify effects and overcome limitations imposed by gravity on the observation and evaluation of selected phenomena and processes, develop technologies related to the requirements of the research, and expand, centralize and disseminate the research data base as widely as possible to the U.S. research and technology community.

STRATEGY FOR ACHIEVING GOALS

In the context of the Microgravity Science and Applications program's mission to develop and utilize the scientific potential of space, ground-based research serves two purposes: first, to find and refine concepts for space experiments: and second, to create a framework of knowledge and expertise in which the full scientific value of space experiments can be realized. The Research and Analysis (R&A) program. through its support of ground-based research, provides the context from which strong, well-defined flight experiments emerge, in which results are interpreted and given scientific meaning, and from which much of the scientific and technological value of space research is transmitted to society. By far the greatest single element of the R&A budget (over 80%) is funding to research grants and contracts awarded through competitive peer review, with over 90% of this funding going to external investigators all across the United States. The remaining R&A funds are used at NASA Centers of Excellence to provide the essential principal investigators and supporting infrastructure. NASA set out at the beginning of the 1990's with the goal of building a research program in the microgravity sciences that would engage the talent and energy of the nation's scientists and engineers to develop the potential of space for research in physical, chemical, and biological processes. Having established a strong foundation for this effort over the last several years through a series of highly successful research solicitations. NASA is working with its community and the participating NASA Field Centers to define and build a dynamic, coherent research program capable of driving a new generation of flight investigations in the coming decade, the beginning of the space station era.

Microgravity research introduces a new dimension, the space environment, to research conducted in well-established scientific and technological areas. The disciplines participating in microgravity research which are the core of current thrusts in science and technology are: (1) Biotechnology: (2) Combustion Science: (3) Fluid Physics: (4) Materials Science; and (5) Selected Studies in Gravitational Physics.

The Biotechnology program focuses on protein crystal growth, a critical element of structural biology and rational drug development, and tissue culture technology, exploring the cellular response to low stress environments in a technology central to contemporary biomedical research. Experiments in space have demonstrated that gravity influences (and sometimes disrupts) protein crystal growth and that reduced gravity can result in improved crystal characteristics. Improved data from protein crystals will allow scientists to better understand the protein's structure. In principle, such information could eventually be used to improve the efficiency of rational drug design. Similarly, growing normal and cancerous mammalian tissues is a technology with enormous medical benefits and applications. Fluid flows found in conventional bioreactors cause shear forces that break apart or damage cell clusters. In a bioreactor developed to study how cells behave in various fluid flows and low shear environments, researchers have found that cells aggregate and allow the study of how cells join together to form tissue.

The Combustion Science program focuses on a ubiquitous physicochemical phenomenon responsible for producing 85% of the world's energy as well as a significant fraction of atmospheric pollution, resulting in continuing hazard to life and property on Earth and in space. Combustion reactions release heat. Under gravity's influence, this heat release causes a flow as the heated gas rises. By reducing this flow in a low gravity environment, important problems such as soot formation in flames, the spreading of fires, the burning of hydrocarbons and limits of flammability can be studied in very fundamental ways.

The Fluid Physics program studies the properties and motions of liquids and gases, providing a conceptual framework in which to understand the role of gravity in physical processes, and a foundation for advances in a spectrum of technologies, from chemical processes to power generation and geotechnical engineering. Scientists study how fluids flow under different conditions, how energy affects fluid flows and many other important scientific and practical issues. Investigators seek the ability to make accurate predictions of how heat and mass are transported in mixtures of fluids and vapor, with profound implications for production and control processes on Earth and in future space engineering applications.

The Materials Science program examines the relationship between processing, structure and properties, and strives to acquire the basic scientific knowledge required to develop new generations of high performance materials in areas including electronic and photonic materials, glasses and ceramics, and metals and alloys. Materials can be divided into crystalline (a certain long range order on the atomic scale) and non-crystalline or amorphous (no long range order). The properties of a material are largely determined by the structure of the material, and is greatly influenced by the process used in forming the material. Gravity-driven phenomena can play a huge role in this triangle of properties/processing/structure. Utilization of the low gravity environment to give insight into materials and materials processing, may result in improvements to production methods and materials on Earth.

Selected studies in Gravitational Physics, including the study of critical phenomena, low temperature physics and other phenomena where the space environment can make possible measurement of physical constants with levels of accuracy that challenge the understanding of contemporary theories in physics. Reduction and control of the forces due to gravity allow

investigations to probe into the depths of physical variables to levels that allow the verification of universal theories which can then be used in a great many fields of physics with much greater confidence.

The Marshall Space Flight Center (MSFC) is the lead center for the materials science portion of the program and the protein crystal growth and biological separations part of the biotechnology program. The Johnson Space Center (JSC) leads research in the cell culture portion of the Biotechnology discipline. The Lewis Research Center (LeRC) has responsibility for the fluid physics and the combustion science disciplines. The Jet Propulsion Laboratory (JPL) is the lead center for the low-temperature physics and gravitational physics portion of the program.

Contractors are utilized in the role of science support at the centers. They are responsible for understanding the science of the investigators they are assigned to monitor, and to assist the external scientists in the utilization of unique facilities at the centers required to carry out some of the low gravity experimentation.

The strategy NASA has devised for achieving excellence in microgravity research is to reach out to the national resources in academic and industrial organizations, and join strong researchers with NASA expertise in microgravity experimentation. The foundation of the effort to engage national scientific resources is the release of solicitations, NASA Research Announcements (NRA's). directed to research disciplines, inviting proposals for research and flight experiment concepts. The proposals selected for funding from the assessment by peer panels of technical experts of scientific and technical merit and need for the microgravity environment. By soliciting for research across a discipline, rather than for specific missions, NASA allows easier entry into the microgravity program for researchers with strong merits but limited experience with the space program. The first of these discipline-directed NRA's was released in 1989. Since then, seven NRA's have been released, and over 900 proposals have been received.

Through collaboration with domestic and international science communities, the program has sought to obtain concrete as well as synergistic investments by other participants. In the area of biotechnology, NASA has joined with the National Institutes of Health (NIH) to obtain laboratory space, diagnostic equipment, and skilled researchers to accelerate the transfer of NASA-developed bioreactor technologies to the broader science community. Through joint cooperative agreements with INTRACELL and the Eli Lily companies. NASA's MSFC has acquired market-valued protein derivatives and diagnostic equipment which support both industrial and government sponsored research in areas of protein crystal growth.

Letters of agreement with Japan and Canada have improved the research facilities available to U.S. ground-based principal investigators. The Japanese have made their highly sophisticated 10-second drop tower facilities available to a broad range of U.S. combustion science investigators. The Canadian Space Agency has developed and offered to the U.S. a large vibration isolation mount that can be used in U.S. parabolic aircraft to provide an improved lower gravity environment on the aircraft which is an integral part of the ground-based research program.

MEASURES OF PERFORMANCE

Complete 19 peer-reviewed studies in Biotechnology -- Sept. 1996	A summary assessment of the results of these studies, which focus on macromolecular crystal growth as well as cellular response to low stress environments, will be included in the Annual Program Task and Bibliography NASA Technical Memorandum for FY 1996.
Complete 31 peer-reviewed studies in Combustion Science -- Sept. 1997	A summary assessment of the results of these studies, which focus on processes of ignition. propagation and extinction during combustion in a low gravity environment, will be included in the Annual Program Task and Bibliography NASA Technical Memorandum for FY 1997.
Complete 60 peer-reviewed studies in Fluid Physics -- Sept. 1996	A summary assessment of the results of these studies, which include aspects of fluid dynamics and transport phenomena affected by the presence of gravity, will be included in the Annual Program Task and Bibliography for NASA Technical Memorandum FY 1996.
Complete 20 peer-reviewed studies in Low Temperature/Gravitational Physics -- Sept. 1995.	A summary assessment of the results of these studies, which include critical phenomena, low temperature physics and other phenomena where significant advantages exist for studies in a low gravity environment, will be included in the Annual Program Task and Bibliography NASA Technical Memorandum for FY 1995.
Complete 50 peer-reviewed studies in Materials Science -- Sept. 1996	A summary assessment of the results of these studies, which include electronic and photonic materials. glasses and ceramics. and metals and alloys, will be included in the Annual Program Task and Bibliography for NASA Technical Memorandum FY 1996.
Complete 5 peer-reviewed ATD projects -- Sept. 1995	A summary assessment of the results of these studies will be included in the Annual Program Task and Bibliography NASA Technical Memorandum for FY 1995.
Complete 5 peer-reviewed ATD projects -- Sept. 1996	A summary assessment of the results of these studies will be included in the Annual Program Task and Bibliography NASA Technical Memorandum for FY 1996.

ACCOMPLISHMENTS AND PLANS

In FY 1994, approximately 80 investigations that had been selected for funding from over 300 proposals received in 1993, began as new projects. The second NRA for biotechnology was released in FY 1994. with proposal evaluation and funding planned to commence in FY 1995. Two discipline conferences, (fluid physics and materials science) with over 300 participants at each, were held in the summer of FY 1994. The participants reviewed the results of ongoing research and discussed opportunities prior to the release of NRA's in early FY 1995. These conferences provide an important forum for new researchers to become acquainted with microgravity research. The low temperature physics community also held a workshop in FY 1994. to share concepts for microgravity research and to continue to define this evolving area of science.

Reflecting the growth experienced by the program and the rising visibility of microgravity research in FY 1995, NASA expects to experience the largest annual volume of microgravity research proposals to date. Already this year, the fluid physics and materials science disciplines have released their second announcements (the first for each was released in August 1991), and the combustion science discipline will release its third. NASA anticipates receiving over 700 proposals in response to these NRA's. To strengthen the ability of NASA Field Centers to support the increasing numbers of investigators interested in conducting microgravity experiments, NASA will be improving its field center resources in 1995. bringing new and refurbished facilities on line. A major expansion of research activity in biotechnology is planned for FY 1995 with the additional funding provided for the NASA/National Institutes of Health cooperative activity, with large growth in the tissue culture program. A number of proposals from research teams for innovative multidisciplinary approaches to biotechnology research, with potential awards of approximately $750,000 per year, are also being evaluated for FY 1995 support.

The FY 1996 request accommodates support of the selection from the 1994 fluid physics, materials science, and combustion science NRA's. Low temperature physics will solicit proposals through the fluid physics NRA. As these disciplines are entering a period of consolidation following vigorous growth in the early 1990's, only modest budget increases are planned that will allow for discipline maturation. The investigations under support at this point will define the first phase of space station microgravity research. Further growth in these disciplines is planned toward the end of the decade, when it is anticipated that space station research will grow in scope and intensity. An NRA for biotechnology is planned for FY 1996.

The principal objective for the R&A program in FY 1996 will be to integrate the investigations selected through the three solicitations released in FY 1995 into the ongoing efforts of the microgravity program. NASA will be working with large numbers of external researchers to define flight experiments with high scientific merit, and with advisory groups as well as the community at large to achieve the focus and coherence required of a strong, productive flight program. A productive research program also requires dynamic flexibility. to keep pace with the progress of scientific and technological knowledge. and in FY 1996 NASA will continue to stimulate new concepts for microgravity research through its plan for discipline conferences. The FY 1996 Biotechnology NRA will provide a definitive opportunity for experiments in tissue culture research and protein crystal growth prior to the launch of the space station.

NASA plans to increase the number of Microgravity Sciences ground-based Principal Investigators to 260 in FY 1996. The number of research proposals received is expected to be 200 in FY 1996. with approximately 480 major journal publications anticipated.

BASIS OF FY 1996 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE FLIGHT PROGRAM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Flight experiments program	(140,300)	78,400	84,200
NASA/MIR research program	(10,200)	11,300	9,300
Space station utilization program	(6,100)	11,800	16,200
(Construction of facilities - microgravity development complex)			(3,000)
Total	(156,600)	101,500	109,700

PROGRAM GOALS

The primary goal of the Microgravity Science Flight program is to advance fundamental scientific knowledge in physical, chemical, and biological principles and to enhance the quality of life on Earth by conducting scientific experiments in the low-gravity environment of space. The results derived from conducting experiments in the Space Shuttle, the Russian Space Station Mir, and the international Space Station will spark the imagination of the growing academic and industrial science community, enhance the nation's technological and industrial base, and foster international cooperation.

STRATEGY FOR ACCOMPLISHING GOALS

Over the last decade, NASA has established an active scientific program in microgravity research using the Space Shuttle. As the program moves toward the next century, the focus will shift toward using the Space Station. The strategy for accomplishing the goal is to continue to pursue the development and flight of the most scientifically worthy experiments in the Space Shuttle and evolving to the Space Station by using the Russian Space Station to mitigate risk in scientific, technological, logistical, and operational planning. The objective of the Microgravity Science Flight program is to provide flight experiment opportunities for a range of scientific investigators in the areas of biotechnology, combustion, fluid physics, materials science, and selected investigations in other phenomena which can benefit from conducting the experiments in the low-gravity environment of Earth orbit. The Flight Experiments program provides hardware for experiments for a wide range of flight opportunities in the Space Shuttle middeck, Spacelab, Space Shuttle cargo-bay experiments, the Russian Mir, and the Space Station. The experiments range from small hand-held single experiments to multirack facility-class experiment hardware accommodating several investigators. The program includes selection definition and development, in-flight operational support and data analysis and archival for all Microgravity flight experiments.

The Flight Experiments program enables the development of an appropriate infrastructure, experiment apparatus. flight opportunities. and advanced technologies to meet the peer-reviewed science requirements. Experiments are developed in all major disciplines, science operations are supported, and flight gathered data and samples are analyzed. The Flight Experiments program also fosters cooperative activities with organizations to combine the research goals of the organizations and create results from flight experiments which have eluded researchers on Earth prior to this point.

The NASA/MIR Research program seeks to mitigate risk in scientific, technological, logistical, and operational planning for the use of the international Space Station. characterize the microgravity environment on Mir. and conduct specific U S. investigations in microgravity science and application research disciplines. The principal parts of the program are the modification of the Space Shuttle experiment apparatus: flight samples, science operations, and data analysis/procedures so they can be used on the Mir by U.S. investigators.

The Space Station Utilization program supports the users to make it a unique laboratory for the U.S. scientific and technology community. The utilization program will support the development of flight experiments, the funding of U.S. Principal Investigators, ground-based facilities, and science operations in the biotechnology, combustion fluid physics, biotechnology, and material science disciplines. When coupled with the Microgravity Space Station Payload Facilities, the NMRP and the Flight Experiments program, these programs constitute the Flight Program activities necessary to sustain the Microgravity Science Research program in the 21st century.

The Cell and Tissue Culture program is lead by the Johnson Space Center (JSC) , with contractor support from Krug Life Sciences Corporation. Both the fluid science and combustion science programs are led by the Lewis Research Center (LeRC), with contractor support from Native American Services Corporation. The materials science and protein crystal growth programs are led by the Marshall Space Flight Center (MSFC) with support from Teledyne-Brown Engineering. The low-temperature fundamental physics and gravitational physics programs are led by the Jet Propulsion Laboratory (JPL).

The European Space Agency (ESA) developed the Spacelab module that is used in the U.S. Microgravity Laboratory (USML) series, Life and Microgravity Spacelab (LMS), and Microgravity Science Laboratory (MSL) mission. In addition, our international partners developed nearly all of the experiment apparatus that flew on International Microgravity Lab-2 (IML-2) and was shared by both international and U.S. investigators. The Spacelab glovebox that will fly on USML-2 was developed by ESA and, in exchange for U.S use of this glovebox on USML-2, NASA will fly two units of the ESA Advanced Protein Crystallization Facility (APCF) in the middeck of the Space Shuttle. Both U.S. and European investigators will use the APCF on this quid-pro-quo agreement with ESA. In addition. there is an agreement being negotiated with ESA for additional flights of the APCF. Each flight would be for two APCF units with a total of 96 protein crystal growth cells where the U.S. investigators would get 48 cells. NASA and ESA are jointly conducting a definition study of the Satellite Test of the Equivalence Principal (STEP) experiment, which will be a candidate for an ESA mission in the 2001-2003 time frame. The Japanese Space Agency developed a large isothermal furnace that flew on IML-2 with investigators from Japan and the U.S. This furnace will be reflown on MSL-1 with U.S. and Japanese investigators. The National Institutes of Health (NIH) has invested billions of dollars of ground-based research in cell culturing. The NASA/NIH agreement on use of NASA's bioreactor technology allows NASA to take advantage of these investments and analysis base to extend the understanding of structure and functions applicable to cell culture flight experiments using the NASA developed bioreactor.

ASURES OF PERFORMANCE

USML-2 Launch -- 4th Qtr FY 1995	USML-2 will focus on the physics of crystallization. fluid dynamics and biotechnology. Investigations will be continued from the highly successful USML 1 mission (6/92) as well as new investigations chosen since that time. Four investigators will study important aspects of crystal growth from the melt and vapor using the newly upgraded Crystal Growth Furnace (CGF). Studies on surface tension driven convection will be expanded past those conducted on USML 1 using the modified Surface Tension Driven Convection Experiment (STDCE).and observations of drop dynamics will be confirmed using the Drop Physics Module (DPM). The Spacelab Glovebox will conduct seven new glovebox investigations chosen in 1992. The Geophysical Fluid Flow Cell (GFFC)will take greatly expanded data during the mission.
USMP-3 Launch -- 2nd Qtr FY 1996	The USMP-3 mission will focus on experiments in Microgravity Materials Science. The French Principal Investigator of the MEPHISTO project will study transport and kinetics of Tin-Bismuth alloys, as well as the influence of small disturbances to the microgravity environment of the Space Shuttle, in order to expand the range of information produced from the previous USMP missions. A modified version of the Advanced Automated Directional Solidification Furnace (AADSF) will be used to conduct a new investigation on crystal growth of semiconductor alloys in which temperature-driven and composition-driven convection cannot be simultaneously reduced in Earth's gravity. the Isothermal Dendritic Growth Experiment (IDGE)will conduct statistical studies of dendritic crystal growth to provide additional information for interpretation of the results from the previous mission. In addition. new U.S. Glovebox Facility will be flown in the Space Shuttle middeck to conduct several new glovebox investigations in microgravity combustion science and spacecraft fire safety.
LMS Launch -- 3rd Qtr FY 1996	The Life and Microgravity Spacelab (LMS) mission will be the first flight of the ESA Advanced Gradient Heating Furnace (AGHF), a new furnace facility available to NASA to conduct town materials science Investigation selected in 1992 on the physics of multiphase solidification. Several ESA Investigations will also be conducted. The Bubble, Drop and Particle Unit (BDPU) will be modified and used to conduct two new types of experiments on this mission.

Spacelab Mir (SL-M) Launch -- 3rd Qtr FY 1995	Mir missions will focus on expanding the current Shuttle-based research program and provide a transition to long-duration missions on the International Space Station. Their objectives are to: (1)reduce the technical risk associated with construction and operation of the International Space Station. Microgravity research during the Mir 1 mission will focus on the characterization of the acceleration environment of the Mir complex which will be used to support researchers with a profile of the acceleration levels present during the performance of their experiments. This characterization will contribute to microgravity experiment strategic planning for later Phase 1 activities and vibroacoustics control planning activities in preparation for Phase II and 111. NASA's biotechnology programs support research with potential technological impact on medical, pharmaceutical. and agricultural industries. Positive results would impact such areas as rational drug design and testing, disease control and treatment, and improve and protect commercially important crops. The Mir missions provide a unique opportunity to advance biotechnology research with multiple and long-duration protein growth experiments which could not be supported in the short time periods of the Shuttle missions. The first of these experiments will be the GN2 Dewar/Freezer.
NASA/Mir 2 Launch -- 1st Qtr FY 1996 NASA/Mir 3 Launch -- 2nd Qtr FY 1996 NASA/Mir 4 Launch -- 4th Qtr FY 1996	These missions will focus on expanding the current Shuttle-based research program and provide a transition to long-duration missions on the International Space Station. Their objectives are to: (1)reduce scientific risk and enhance long duration experiment performance and science utilization for the International Space Station; (2)conduct combined international space operations and joint space technology demonstrations; and (3)provide early opportunities for extended scientiflc, technologic and engineering research and testing.

ACCOMPLISHMENTS AND PLANS

Flight Experiments Program

During FY 1994. two major microgravity missions were conducted: the second United States Microgravity Payload (USMP-2) and the second IML-2. The USMP-2 successfully completed four major experiments and demonstrated the effectiveness of "telescience," (i.e. conducting science experiments by remote control). This is extremely important preparatory work for the Space Station. The results of the materials science, fluid physics and biotechnology experiments will add to the understanding of specific physics and science phenomena. On both missions, the space acceleration environment was characterized with acceleration monitoring systems. The IML-2 mission involved the Space Shuttle transporting the ESA Spacelab module to orbit where

International- and U.S.-developed experiment apparatus was used. The IML-2 mission flew 82 experiments, of which 42 were jointly-sponsored by NASA and the international partners.

During FY 1995, the USML-2 mission is planned. The mission uses the Spacelab with U.S.-developed experiment apparatus and U.S. Principal Investigators (PI's). In addition to USML-2, research will be conducted in four biotechnology and one combustion middeck experiments during FY 1995.

FY 1996 funds are required to continue experiment payload development for use in the Space Shuttle middeck, Spacelab. and Space Shuttle cargo bay for future missions. These include the Life and Microgravity Spacelab (LMS) mission, the Microgravity Science Laboratory (MSL-1) mission and the USMP series of missions. During FY 1996, the LMS and USMP-3 missions will be conducted. Also, the funds support the flight Principal Investigators and the data analysis during and after the mission's completion. NASA plans to fund 40 Microgravity Sciences flight Principal Investigators in FY 1996. encompassing 106 major flight investigations and 9 small payload investigations.

In FY 1996. funding is required to modify and expand the existing Marshall Space Flight Center (MSFC) Building 4493 into the Microgravity Development Complex (MDC). This new project will consolidate and focus microgravity materials science, biotechnology and glovebox flight experiment activities, reducing total MSFC science facilities and costs, and provide a facility for the in-house assembly and test of the large Space Station Furnace Facility payload. The MDC will house flight instrumentation prior to launch, the complementary ground-based research hardware, and the User Operations Facility for MSFC microgravity science payloads.

NASA/NIH Program

During FY 1994, NASA's Office of Life and Microgravity Science and Applications and the NIH's Institute of Child Health and Human Development entered into an inter-agency agreement regarding Biomedical and Behavioral Research. The NIH has invested billions of dollars in tissue culturing activities, and NASA has achieved a breakthrough in the engineering of tissue which allows for cellular growth, aggregation. and the development of in vivo-like structures through use of the NASA-developed bioreactor. Funds for this program enable the continued collaboration of the two agencies, the accelerated transfer of NASA bioreactor technology to NIH and the external research community, and the identification of tissue culture experiments which would benefit from being conducted in a low-gravity environment. An agreement was reached in FY 1994 to transfer the bioreactor technology to the Institute of Child Health and Human Development to conduct research on the AIDS virus cultured in lymph nodes. This initial pathfinder collaboration is planned to continue through FY 1998.

The cell culture technologies and protein crystal growth results will receive the major emphasis for the next 5-6 years, but it is anticipated that many other areas of cooperation will evolve from preliminary results. Over the past years, NASA has explored many aspects of the growth of protein crystals and the development of tissue culturing technologies which offer great promise. Similar types of efforts are being explored with several other institutes. This program will stimulate the joint agreements with other Federal agencies.

Low-Temperature Research

In FY 1996, the objective is to continue the integrated microgravity low-temperature science ground and flight program, with emphasis on low-cost, increased university and industry involvement, advanced technology development, and transfer of this technology for commercialization. Emphasis is placed on public and student involvement. Additional funding has been allocated for two flight experiments. The first flight will be for the peer-reviewed and selected experiment to study the thermal conducting behavior of liquid helium under non-equilibrium conditions. The second will be a continuation of the low-temperature research activities selected in the peer review process. These experiments will be the third and fourth in a series of low-temperature science flights. The funding provides for the experiment development and mission operations for the experiments which will be conducted in the cargo bay of the Space Shuttle.

NASA/MIR Research Program

During FY 1994. the Space Accelerations Measurement System (SAMS) was delivered to Mir and recorded the acceleration levels on the Russian space station. The first Space Shuttle docking mission with Mir will take place in FY 1995, when a protein crystal growth experiment will be delivered to Mir. In addition, the remainder of the microgravity experiment apparatus planned for Mir will be delivered to Russia for installation in the Priroda module and subsequent Shuttle flights.

During FY 1995, the Space Shuttle will dock with Mir three times and the Priroda module will be launched and attached to Mir. Most of the U.S. experiments will be located in the Priroda, utilizing the Space Shuttle to transport experiments, samples and data to and from the Mir. The continued NASA/Mir program will include the launch of U S. hardware to Mir and support of science operations for the experiments.

Space Station Utilization Program

The program consists of planning and integration activities, developing operations support procedures, and developing experiment unique research hardware for ISSA. The first major consolidated operations and utilization plan, developed using inputs from microgravity hardware developers and planners, will be assembled in FY 1995 and further refined in FY 1996. To prepare for microgravity operations on the Space Station, work continues to define operational requirements and develop telescience techniques. Operational capability for microgravity research will be developed at MSFC, JSC. and LeRC. In FY 1995, the LeRC will support several microgravity experiments on two Space Shuttle missions and on the Mir Space Station. In FY 1996, the LeRC will continue to operationally support experiments on the Space Shuttle and conduct a telescience demonstration. As the operational era of the Space Station moves closer. the program focus in FY 1996 will shift toward experiment development and planning with specific emphasis in the combustion and fluids disciplines.

BASIS OF FY 1996 FUNDING REQUIREMENT

SPACE SHUTTLE/SPACELAB MISSION MANAGEMENT AND INTEGRATION

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Space shuttle/spacelab mission management and integration	108,700	113.000	85.400

PROGRAM GOALS

The goals of this program are twofold: (1) provide physical, analytical, and operations integration support to achieve NASA mission objectives for the science and technology communities: and (2) ensure integrated scientiflc. technological, and commercial user advocacy and coordination of requirements for the next generation of space laboratories.

STRATEGY FOR ACHIEVING GOALS

In order to meet the program goals and objectives, NASA performs the mission planning, integration, and execution of all NASA Spacelab, Spacehab. NASA/MIR Research Program (NMRP). and other attached Space Shuttle payloads to carry out a wide variety of space research. The program also supports the common small science payloads that use locker spaces in the Space Shuttle's lower crew compartment. Activities include system management and engineering development of flight support equipment and software: development of interface hardware: payload specialist training and support: integration of the science payloads with the Spacelab system: payload flight operations: and data dissemination to experimenters. Mission management activities are dependent upon the specific mix of missions in a particular year.

In addition, through this program, NASA carries out systems engineering efforts to develop and evaluate strategies and processes for satisfying current and future research mission objectives. These tasks not only address the current Space Shuttle/Spacelab mission integration processes, but, based on this knowledge base, they define and support new effective and efficient processes and tools for carrying out integrated research advocacy. requirements coordination. mission planning and operations for future space platforms. In particular, the program is investigating ways to apply the engineering and operations lessons learned in the Spacelab program and the NMRP to the International Space Station Alpha (ISSA) program to achieve greater efficiencies.

The principal NASA Centers which conduct activities in support of this program are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), and the Marshall Space Flight Center (MSFC). In FY 1996, JSC will provide the analytical integration and operations level project management support for the NMRP missions. The KSC will provide the physical hardware science payload integration project management support for the NASA science payloads on the individual Space Shuttle flights. MSFC will provide the analytical integration and operations level project management support for the Life and Microgravity Spacelab (LMS) and the United States Microgravity Payload (USMP)-3. In FY 1996. the primary contractors that will be supporting the program at the

centers are: Martin-Marietta Services, Inc. at JSC: the McDonnell Douglas Corporation's Payloads Ground Operations Contract (PGOC) at the KSC; and Teledyne-Brown Engineering at MSFC. At JSC. Martin-Marietta provides payload mission integration support for the missions managed by the JSC. At KSC, the primary PGOC functions include: processing flight hardware experiments for Spacelab and partial payloads, manifest scheduling and work control support, logistics support and sustaining engineering modifications to facilities and systems, and computational services for the Payload Operations Computer Network. At MSFC, Teledyne-Brown provides payload mission integration support for the missions managed by MSFC.

MEASURES OF PERFORMANCE

The most significant measure of performance is the provision of an integrated system that ensures successful accomplishment of the science payload objectives. Although not directly responsible for the success of a particular experiment, the mission management organization is responsible for ensuring that all necessary planning and integration of the collected set of instruments have been comprehensively completed and fully coordinated so that the experimental hardware in concert with flight crew performance and ground control direction have the opportunity to conduct the planned science activities. Science payload objectives vary considerably depending upon the type of mission supported (module missions, pallet/MPESS missions or Space Shuttle middecks) and the type of scientific investigations performed (microgravity. life sciences, earth and stellar observations). Depending upon the type of payload, performance is measured in terms of the number of primary missions, the number of middeck missions, and the number of hours of science payload operations actually performed.

For the missions conducted in FY 1994, mission management performance has been highly successful:

Astro-2 Launch - 2nd Qtr FY 1995	This Spacelab pallet mission is a reflight of the ultraviolet portion of the Astro-1 astrophysics Spacelab payload, which flew in December 1990. It consists of three experiments which are conducted by three separate and complementary ultra-violet telescopes.
Spacelab Mir (SL-M) Launch - 3rd Qtr FY 1995	This Spacelab module mission will offer an opportunity to perform research aboard the Space Shuttle and the Russian Mir space station while the two are docked together. The research to be performed will be in the fields of life sciences and microgravity science. The mission will also allow for a better understanding of Russian medical monitoring, countermeasures and operational medicine programs. Important insight into space station operations will be gained through the joint operations.

USML-2 Launch- 4th Qtr FY 1995	The objectives of this Spacelab module mission are to conduct scientific and technological investigations in materials, fluids, combustion and biological processes and to explore potential applications of space for commercial products and processes. Fifteen investigations have been base-lined for the this mission, as well as seven additional U. S. investigations to be conducted in the USML-2 Glovebox facility provided by the European Space Agency in a quid pro quo arrangement.
USMP-3 Launch - 2nd Qtr FY 1996	This Spacelab pallet mission will perform materials processing and other experiments in the microgravity space environment with inflight monitoring of phenomena, sample production, and postflight analysis of samples. Such activities are expected to significantly advance the basic knowledge of materials science and help develop better products and technology for use on Earth and in space.
LMS Launch - 3rd Qtr, FY 1996	This Spacelab Module mission will perform scientific investigations in the fields of material science, fluid physics, protein crystal growth, and biotechnology. Human and plant studies and a subset of investigations previously planned for SLS-3 will also be conducted.
NASA/Mir 3 Launch - 2nd Qtr, FY 1996 NASA/Mir 4 Launch - 4th Qtr, FY 1996	Life sciences research on Biorack will investigate cellular functions and developmental processes in plant and animal tissues. Microgravity objectives will be focused on reducing scientific risk and enhancing long duration experiment performance and science utilization in preparation for ISSA. Mission Management and Integration functions will be performed by Spacehab, Inc.

ACCOMPLISHMENTS AND PLANS

In FY 1994, the Space Shuttle/Spacelab Mission Management and Integration program successfully managed the five Spacelab missions that were scheduled for completion: the second flight of Space Life Sciences (SLS-2), the second flight of the US Microgravity Payload-2 (USMP-2).the flight of the Space Radar Laboratory (SRL-1), the second flight of the International Microgravity Laboratory (IML-2), and the flight of the Lidar In-Space Technology Experiment (LITE-1).

In the first quarter of FY 1995, two additional Spacelab missions were successfully supported by the program: the second flight of the SRL-2 and the third flight of the Atmospheric Laboratory for Applications and Science (ATLAS-3). Three additional Spacelab missions are scheduled to be completed within the remaining months of FY 1995: the second flight of the Astronomy mission

(ASTRO-2), the second flight of the US Microgravity Lab-2 (USML-2) and the Spacelab-Mir (SL-M), the first of the seven-flight NASA/MIR Research Program.

Mission management activities in support of missions planned for FY **1996** have also commenced for the remaining flights in the NMRP **as** well **as** for the LMS. Long-term mission planning effortshave also been initiated in support of the Space Station.

In FY **1994** and FY **1995.** the program conducted two separate comprehensive reviews with the intent of streamlining its operational procedures and achieving substantially lower costs for the mission management of the Spacelab programs. The Process Action Team for Spacelab Mission Management identified a number of cost reduction activities at the Center-level management and integration organizations. Those cost reductions have generated savings of over **$14** million. The Spacelab Re-Engineering Team was chartered in the fall of **1994** to review the program and to further streamline the processes and reduce the mission management budget. The team has nearly completed its work and will recommend improved processes which are expected to generate additional savings in mission management.

Mission management activities in FY **1996** will continue with the launch of several module missions LMS. NASA/Mir **3** and NASA/Mir **4** and a key microgravity pallet mission **(USMP-3).** Successful preparation and launch of the LMS mission in FY **1996** will require a highly-accelerated schedule of mission management events. Other mission planning efforts will **also** be performed in support of the final three flights of the NMRP, the first flight of the Microgravity Science Laboratory-1 and the fourth flight of the **USMP-4.** In the third quarter of this year, NASA will begin the conduct of continuous on-orbit research aboard the Mir with **U.S.** and Russian astronauts. Space Station planning and integration efforts will intensify **as** the First Element Launch date of the Space Station approaches (December **1997).**

In **FY 1996,** systems engineering efforts will continue to support methodologies for advocacy and coordination of **U.S.** research requirements vis-a-vis carrier programs and implementation of processes and tools for mission planning for **U.S.** payloads on future space platforms. primarily the phase II and 111 of the international Space Station.

BASIS OF FY 1996 FUNDING REQUIREMENT

AEROSPACE MEDICINE AND OCCUPATIONAL HEALTH

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Aerospace medicine and occupational health	(2,700)	7,000	7.000

PROGRAM GOALS

The Aerospace Medicine and Occupational Health program goals are to: (1) provide for the health care and well-being of all NASA employees in their ground- and space-based work environments: and (2) promote applications of knowledge gained and technologies developed in the public and private sectors.

STRATEGY FOR ACHIEVING GOALS

The Aerospace Medicine and Occupational Health program leads the Agency in the areas of Aerospace Medicine, Global Health Applications and Occupational Health. The primary objective of the Aerospace Medicine program is to maintain the health and productivity of astronauts, thus increasing the probability of success of flight missions. The scope of work includes the refinement of standards and requirements for operational medicine in support of space flight: provision of ground-based medical support for human space flight mission operations: and ensuring development of hardware, training. and protocols for maintaining clinical care readiness on-board spacecraft.

The Global Health Applications program transfers the NASA knowledge and technology of aerospace medicine and occupational health to a variety of domestic and international endeavors that contribute to national competitiveness. education, and quality of life. This work is accomplished via publications and use of other media to inform others of our aerospace medicine and occupational health practices: promoting the incorporation of these practices in educational curricula: and transferring the technologies developed for medical care of space flight crews to terrestrial health care applications such as the use of tele-medicine to improve the access to health care in rural and underserved areas and to support medical responses to disaster-stricken areas. both in the U. S. and abroad.

The Occupational Health program establishes policies and manages implementation of NASA-wide occupational and environmental health programs and services. These include provision of immediate medical care for acute Illnesses, accidents and injuries in the workplace: controlling and responding to exposure of employees to toxic materials. hazardous environments and harmful physical agents in the workplace: implementing state-of-the-art preventive medicine and wellness programs: and assuring Agency compliance with legal and regulatory requirements for occupational health.

The Johnson Space Center (JSC) and Headquarters are the principal centers involved in the Aerospace Medicine program. The JSC will manage the tele-medicine efforts in support of mission operations, and the medical applications activities. Funding will be provided to the Lewis Research Center (LeRC) to support Spacebridge to Russia. Wright State University and the University of Texas Medical Center are the major contractors for the Aerospace Medicine program.

The Russian Space Agency is providing some of the infrastructure in support of U.S. astronaut medical health monitoring for the Space Shuttle/Mir missions.

MEASURES OF PERFORMANCE

	FY 1994 ACTUAL	FY 1995 PLAN	FY 1996 PLAN
No. of workers' compensation claims filed	301	286	295
No. of days to process workers compensation claims	8 days	7 days	6 days
No. of papers/presentations at national meetings	20	24	29

U.S./Russian Medical Policy Board - 2nd Qtr, FY 1995	This establishes the U.S./Russian Medical Policy Board which validates medical requirements, standards, protocols, and flight rules for all joint U.S./Russian missions.
First Draft International Space Station Medical Requirements - 4th Qtr, FY 1995	This effort initiates the documentation of the medical requirements for flight crew performance and well-being and the requirements for conduct of medical research needed for extension of on-orbit stay time or for other specific crew health related issues.
Operational Tele-medicine System - 4th Qtr, FY 1995	This effort establishes the configuration of the operational tele-medicine system and initiates its use in support of flight crew activities.
Medical Risk Assessment - 2nd Qtr, FY 1996	This effort completes a comprehensive risk assessment and review of known medical requirements in support of international space station mission activities.
Global Medical Network - 4th Qtr, FY 1996	This effort provides NASA-support to the development and operations of the global medical network for telemedical transactions involving other national and international organizations.

ACCOMPLISHMENTS AND PLANS

FY 1994 accomplishments included successful completion of the international Tele-medicine Demonstration program (Spacebridge to Moscow) and sponsorship of the Second NASA/Uniformed Services University of Health Services (USUHS) International Conference on Tele-medicine. Programs were initiated with the Pan American Health Organization and the Third World Foundation to support disaster preparedness and response, enable epidemiological data collection, and provide worldwide access to critical medical information (World Medical Network). The Advanced Communication Technology Satellite experiment was successfully executed to demonstrate small Earth station use for high resolution image transfer (via a fiber optic opthalmascope). A comprehensive tele-medicine demonstration was presented to members of the Congress. A program to identify specific NASA high-speed computing, advanced image processing, and data transmission capabilities which have potential for application to health care problems was also initiated in FY 1994.

Epidemiological studies evaluating long-term consequences of space flight and analog (medical) populations were continued. Medical technologies and procedures for development of inflight medical care were evaluated in zero gravity and static testbeds. The Wright State University Aerospace Medicine Residency program graduated 6 physicians who are eligible for Board Certification in this highly specialized field. These clinical medicine responsibilities support Shuttle Operational Medicine and were transferred to the Aerospace Medicine and Occupational Health Division in 1994 with the applicable funding from the Life and Biomedical Sciences and Applications Division.

FY 1995 plans for the program include: (1) establishing computer connectivity, voice/fax, and video conferencing capabilities with Russia and the Ukraine to enable consultations in that those regions: (2) supporting development of the Pan American Health Organization/Third World Foundation global medical network; (3) developing a network of medical experts for all telemedical transactions (e.g., flight crew or disaster recovery): (4) completing the development of the Star City (Russia) tele-medicine system: (5) initiating the clinical and academic testing of the Clinical Practice Library of Medicine, a computer-based medical library; (6) initiating a comprehensive risk assessment and review of medical requirements for space flight during long duration NASA/MIR Research Program (NMRP) and the international Space Station missions: (7) initiating the development of medical requirements for research in order to ensure the timely availability of adequate procedures, protocols and countermeasures to maintain and enhance human health and performance during extended duration missions: (8) providing operational medical support for Space Shuttle missions and long duration NMRP missions: and (9) establishing a Joint Medical Policy Board and developing joint medical operations requirements documents for the NMRP missions.

FY 1996 plans are to continue development and utilization of the operational tele-medicine system for medical consultations between U.S. and Russian sites and provide operational medical support for missions on NMRP and Space Station. The program will also: (1) develop medical risk assessments and requirements in preparation for Space Station: (2) conduct clinical testing of the Clinical Practice Library of Medicine with extensive field evaluation at NASA Centers: (3) finalize development and initial operation of the global medical network In support of all telemedical transactions; (4) develop and refine the NASA high-speed computing and medical imaging applications for transfer to the health community: and (5) initiate collaborative efforts with national and international agencies to apply NASA-derived technology for health applications.

SPACE STATION PAYLOAD FACILITIES

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Life sciences payload facilities	24,000	42,900	53,900
Microgravity payload facilities	13.000	32,000	65,600
EXPRESS racks/laboratory support equipment	--	15,600	17,800
To	37.000	90.500	137.300

PROGRAM GOALS

The international Space Station will be the worlds premier facility for studying the role of gravity on biological, physical and chemical systems. NASA plans to utilize the Space Station as an interactive laboratory in space to advance fundamental scientiflc knowledge and to contribute new scientiflc discoveries for the benefit of the United States and to accelerate the rate at which it develops beneficial applications derived from long-term duration, space-based research. The program will deliver the capability to perform unique, long-duration, microgravity-dependent, space-based research in cell and developmental biology, plant biology, human physiology, biotechnology, fluid physics, combustion science, materials science and benchmark physics.

STRATEGY FOR ACHIEVING GOALS

As one of the primary NASA users of the Space Station, the Life and Microgravity Sciences and Applications program sponsors a robust program to develop flight experiment apparatus, ground-based facilities and operations protocols needed to make the Space Station's unique capabilities available to the United States. The program includes life sciences payload facilities, microgravity payload facilities, laboratory support equipment and EXPRESS rack development.

Life Sciences Space Station Payload Facilities

The Life Sciences Space Station Payload Facilities program will develop three important hardware facilities: Human Research Facility (HRF), the Gravitational Biology Facility (GBF), and the Centrifuge Facility (CF).

The HRF project will define and develop space flight research hardware to serve a number of closely related objectives. The HRF hardware suite will enable the standardized, systematic collection of data from the Space Station's crew members, which the medical and research community will require in order to assure crew health. Once verified on-orbit, the HRF will also be used to conduct basic and applied human research and technology experiments.

The GBF project will design, develop, and conduct the on-orbit verification of Space Station research equipment to support the growth and development of a variety of biological specimens, including animal and plant cells and tissues, embryos. fresh and salt water aquatic organisms, insects, higher plants, and rodents. The GBF will support specimen sampling and storage, as well as limited analysis activities. The GBF's modular design will accommodate the incremental development of experiment capabilities, in a manner consistent with evolving ground and flight science needs of the research community.

The CF project will design, develop, and conduct on-orbit performance verification of two habitat holding systems, a two-and-a-half meter diameter centrifuge rotor, centrifuge glovebox and a service system rack. The project will also develop a biotelemetry system to support ground-based data analysis of in-flight experiments.

To ensure that the GBF and CF projects develop high-yield science, the projects have established a science working group of leading scientists in cell, developmental, and plant biology. The science working group is composed of leading researchers from universities and government (National Institutes of Health (NIH), the National Science Foundation (NSF), and the NASA). The working group represents the science community to the facilities projects, helps the projects define requirements, reviews hardware design concepts, and they perform and review science tests to refine science requirements.

Several of NASA's Centers lead the development of the component projects funded within the Life Sciences Space Station Facilities program. The Johnson Space Center (JSC) will lead the development of the HRF. The Ames Research Center (ARC) will lead the development of the GBF and the CF. The Kennedy Space Center (KSC) will provide support to the ARC during the development of the GBF and will also provide payload integration services prior to the launch of the facilities and their experiments.

Life Sciences is working closely with contractors to develop the ISSA facilities. The HRF development effort will be managed primarily as an in-house effort at the JSC but will be supported primarily by Martin-Marietta and Krug Life Sciences. Martin-Marietta will provide project engineering and related services in support of HRF hardware development and modification. Krug Life Sciences will support science requirements development and definition at the JSC. Although the GBF and the CF projects will rely upon different procurement strategies, both projects will rely heavily upon support contractors. The Bionetics Corporation will support science definition and development for both the ARC projects, but the two projects will adopt different hardware! engineering and development strategies. Martin-Marietta (or a successor) will support an in-house the ARC development effort for the GBF the CF project anticipates that it will select and direct a prime contractor to develop the major CF hardware components.

The Life Sciences Space Station Facilities program actively pursues international participation. For example, the GBF project has contacted the space agencies of Japan, Germany, and Canada soliciting participation in the development of an aquatic habitat. A multilateral users working group, consisting of representatives from all the major ISSA participating countries. has agreed to principles for eliminating unnecessary duplication of laboratory support hardware. NASA and the European Space Agency (ESA) also have a bilateral agreement to develop four flight copies of a -80° C freezer. The program will pursue other agreements of this sort in order to increase the science returns and the economies of the ISSA program.

Microgravity Space Station Payload Facilities

The Microgravity Sciences Space Station Payload Facilities program will develop three major facilities for the Space Station: the Biotechnology Facility (BTF), the Fluids and Combustion Facility (FCF), and the Space Station Furnace Facility (SSFF). These facilities, coupled with investigator-class payloads, will support a wide array of research in biotechnology, combustion science, fluids science, materials science and gravitational physics.

The BTF supports protein crystal growth and studies on the maintenance and response of mammalian tissue cultures in a microgravity environment. The facility will provide a support structure as well as integration capabilities for individual biotechnology experiment modules. Its modular design will provide the flexibility to accommodate a wide range of experiments in cell culturing and protein crystallization. The facility will accommodate changes in experimental modules and analytical equipment in response to changes in science priorities or technological advances.

The FCF supports research on interfacial phenomena, colloidal systems, multiphase flow and heat transfer, solid-fluid interface dynamics, and condensed matter physics, and definition of the mechanisms involved in various combustion processes in the absence of strong buoyant flows. The facility core will provide common support systems for both the combustion and the fluids modules. The Fluids Module Experiment Rack will be designed to accommodate several multi-purpose experiment modules that are individually configured with facility-provided and experiment-specific hardware to support each fluids experiment. The Combustion Module will house a combustion chamber that is equipped with ports to allow an array of modular diagnostic systems to view the experiment.

The SSFF is used to study underlying principles necessary to predict the relationships of synthesis and processing of materials to their resulting structures and properties. The facility core, which will provide the main interface to the Space Station services, will consist of furnace subsystems common to many types of investigations. The experiment modules will be composed of multi-user or investigator-unique modules that will be designed for high reliability and long life. NASA will be able to reconfigure the modules and will have capability of on-orbit reconfiguration to support many different types of investigations. It is anticipated that cooperative efforts with the international science community will assist in the development of some discipline-specific furnace modules for use by the U.S. science community, thus leveraging the hardware development investments undertaken by NASA.

The microgravity facilities projects follow a standard plan of conducting the early, definition phase 'in-house" at the managing NASA Field Center, with a decision made at the end of the definition phase on the method of pursuing full scale development (e.g., 'in-house" or by competition and award to an external contractor). The BTF project is led by JSC, with contractor support from Krug Life Sciences Corporation. This project is currently in the early definition phase and plans are for JSC to design the BTF and compete the fabrication, assembly, test and integration.

The FCF is led by the Lewis Research Center (LeRC), with contractor support from Native American Services Corporation. This project is currently in the early definition phase and plans have not yet been defined for the full scale development phase. The SSFF is led by the Marshall Space Flight Center (MSFC). This common or 'core system" project is currently in the full scale development phase as an in-house project, with selected fabrication, testing and support services tasks under competitively-

awarded contracts. The experiment module projects are currently in the early definition phase, with plans to complete and contract the full scale development of modules as they complete definition phase.

The microgravity facilities projects actively pursue international participation. For example, the first International Workshop on Furnaces for the international Space Station was held in Europe in June 1993. with participation of NASA, DARA/DLR, NASDA, CSA, ESA and CNES. From this workshop, NASA proposed joint scientific and equipment programs with both ESA and CNES whereby they would provide Furnace Experiment Modules for the NASA SSFF. A follow-up workshop is planned in February 1995 in the United States. A similar workshop is also in preparation for the fluid physics and combustion communities in the United States in April 1995. NASA and ESA also have a bilateral agreement in principal to develop a Microgravity Sciences Glovebox whose capabilities are specified by NASA and will be available for use by all international Space Station microgravity science researchers. As part of this agreement. ESA has proposed to develop new generation protein crystal growth experiment apparatus and share use of it with NASA. This will complement equipment planned for the BTF.

Express Racks and Laboratory Support Equipment

In addition to the major facility-class payload facilities. NASA plans to fly smaller, less complex payloads on the Space Station which will typically have more focused research objectives and shorter development time cycles. The EXPRESS (Expedite the Processing of Experiments to Space Station) rack project provides a means for accommodating these smaller payloads. The EXPRESS rack will enable a simple, streamlined analytical and physical integration process for small payloads by providing standard hardware and software interfaces. The project includes a precursor flight of an EXPRESS rack in FY 1997 on the MSL-1 Spacelab mission. EXPRESS racks will be available to support initial payload operations in the U.S. Laboratory on the ISSA.

The laboratory support equipment (LSE) which the program will finance includes such items as the ISSA refrigerators and freezers, dosimeters, incubators, electro-magnetic shielded locker, micro-mass measurement device, microscopes. gloveboxes, and fluid handling tools. LSE will be shared with other Space Station users. The items are managed by the NASA Field Center responsible for leading development of the Space Station Payload Facility which will be the primary user of the LSE.

MEASURES OF PERFORMANCE

HRF Preliminary Requirements Review Rack 1 - 3rd Qtr, FY 1995	This review establishes the project development plan and ensures that research/science objectives have been properly translated into statements of requirements.
HRF Preliminary Design Review - Rack 1 - 1st Qtr, FY 1996	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.

GBF Critical Design Review - Rack 1 - 4th Qtr, FY 1996	This review verifies the suitability of the design in meeting the specified requirements and establishes its "build-to" project baseline. 90 % of flight drawings should be complete at this stage.
CF RFP for Centrifuge Hardware Procurement - 2nd Qtr, FY 1995	This milestone marks the release of the Request for Proposal for the Centrifuge Hardware.
CF Hardware Development Contract Start Date - 1st Qtr. FY 1996	Contract Start Date will initiate the Design, Development and Testing of the Centrifuge Hardware.
BTF Critical Design Review - 4th Qtr, FY 1996	This review verifies the suitability of the design in meeting the specified requirements and establishes its "build-to" project baseline. 90 % of flight drawings should be complete at this stage
FCF Core System Conceptual Design Review - 1st Qtr, FY 1995	This review establishes the conceptual design of the hardware so that the follow-on Phase B can be initiated.
FCF Core System Requirements Definition Review - 2nd Qtr. FY 1996	This review establishes full scale development plans required for go ahead for development.
SSFF Core System Preliminary Design Review - 1st Qtr, FY 1995	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10 % of the flight drawing should be complete at this stage.
SSFF Core System Critical Design Review - 2nd Qtr, FY 1996	This review verifies the suitability of the design in meeting the specified requirements and establishes its "build-to" project baseline. 90 % of flight drawings should be complete at this stage.
EXPRESS RACK/MSL-1 Delivery to KSC - 3rd Qtr, FY 1996	At KSC the initial EXPRESS Rack that will fly on M S L 1 integrated with the initial payload and processed in preparation for launch in FY 1997.

ACCOMPLISHMENTS AND PLANS

Life Sciences Space Station Payload Facilities

Human Research Facility

During FY 1994, NASA established the HRF's project objectives, conducted Phase A/B studies to identify and select technologies for use in the project, established project organizations, support infrastructures, databases, and began building relationships with the Space Station Project office. An Integrated Product Development Lab (IPDL)was established at JSC during the year to support prototype development of various hardware components for the HRF and for other Space Station-era flight development projects. Prototype engineering and testing has been initiated at the IPDL facility.

The HRF project considered various procurement and development strategies during FY 1994 and determined that existing life sciences flight hardware can support the project's research requirements adequately. The project will modify flight hardware during FY 1995 and beyond. It will develop some new hardware, but the project has determined that no prime contracts for major hardware development will be necessary during the project's life. JSC plans to rely upon its in-house contractor, Martin-Marietta, for hardware engineering and development support.

During FY 1995, the HRF project's efforts will concentrate on finalizing the science requirements by taking advantage of a newly-formed science working group. The project will begin modification and development of an HRF "Rack 0 to fly the Space Station precursor research on the last two NASA/MIR Research Program flights. The project will develop procedures for conforming to Russian policies and procedures related to biomedical monitoring and countermeasures. During FY 1996. the HRF project will work toward the deployment of four racks of research hardware: one in FY 1999, one in FY 2000, and two racks in FY 2004.

Gravitational Biology Facility

The GBF project proceeded with Phase A/B studies for the space and ground segments during FY 1994. The project achieved considerable progress in defining its science requirements during the year. A number of science questions which the project formulated during the year will precede hardware! prototyping and development in subsequent years. Through year-end 1994, the GBF project had awarded eleven peer-reviewed studies to universities, small businesses, and NASA Specialized Centers of Research and Training (NSCORTs). By year-end, the project had also initiated several collaborative studies with other NASA Field Centers and the Wisconsin Center for Space Automation and Robotics (a Center for Commercial Development of Space).

In FY 1995, the GBF activities will focus on the development of detailed system specifications for equipment and system-level designs for both the space and ground segments. A system requirements review and a system design review are scheduled for the second and fourth quarters of FY 1995, respectively. FY 1996 efforts will provide for the completion of the initial design of the first rack of the GBF hardware. The GBF will conduct a preliminary design review for the first rack during the second quarter of the year, and it will proceed with detailed rack design during the remainder of the year. FY 1996 resources will also support the development of habitat science evaluation hardware for tests by members of the science community, prior to critical design review

in the fourth quarter. These science tests will evaluate science utility of the GBF habitat designs. The GBF project will conduct a systems requirements review for the second GBF rack, and the project expects to complete Phase B studies for the second rack by the end of the year. The first complement of GBF hardware (Rack 1) is currently scheduled to launch to the ISSA during FY 1999 followed by a second suite of hardware (Rack 2) in FY 2000.

Centrifuge Facility

The CF project's FY 1994 activities deviated considerably from previous project milestones and plans. The project's design, resource estimates. and procurement schedules all changed following an intensive Headquarters/Ames Research Center (ARC) joint review of the project. By year-end 1994 the Life and Microgravity Sciences and Applications Advisory Committee had endorsed the changes derived from the year's review. In June of the year, the Associate Administrator for Life and Microgravity Sciences canceled a procurement solicitation for Centrifuge hardware development, and the project had altered project milestones and activities to conform to the revised project direction.

The revised CF project has reduced its resource requirements by more than $100 million during the remainder of the development period (FY 1995 through FY 2000). compared to previous estimates. The new project schedule accelerates the centrifuge launch by three years and, although the project design has been simplified, NASA believes that essential science capabilities will be preserved. As an example of the improvements generated by the 1994 CF redesign, the project has agreed to collaborate with the GBF in the development and financing of plant habitats. Likewise, the CF project will draw on work already underway at the ARC to reduce the requirements and improve the performance of Advanced Animal Habitats.

During FY 1995. the CF project will develop and release a new solicitation for the Centrifuge procurement, continue in-house hardware development and test bedding, and proceed with science requirements definition. The project expects to release a new procurement solicitation before the start of the third quarter of the year. Habitat components will be the focus of hardware development activities during the year, and conceptual designs will be completed for such things as an active mass-balance for the Centrifuge rotor. A rodent metabolism study being performed by the Bioenvironmental research Laboratory at the University of Illinois at Urbana-Champaign will be completed, as will the rodent acoustic tolerance testing being done at San Jose State University. In response to requirements specified by the CF/GBF science working group, a variety of new studies will be initiated.

The CF project will select the new hardware development contractor early in FY 1996. Consistent with the project's procurement approach, the new prime development contractor will build the centrifuge rotor. the habitat holding racks, and the support rack. The CF project expects to complete the facility-level preliminary requirements review during FY 1996, and the project will continue to support science studies to evaluate and improve upon hardware designs and configurations. The centrifuge rotor and service system are now scheduled to launch to the ISSA during FY 2001. The first habitat holding facility rack will launch during FY 2000.

Microgravity Space Station Payload Facilities

Biotechnology Facility

In FY 1994, the BTF project conducted a functional review to identify requirements from investigators. An engineering model of the facility was developed along with a smaller version to be supplied to the investigators to solidify the design. The facility simulators were delivered early in FY 1995 to investigators for test and check out. An independent assessment of the facility will be held in March 1995. A requirements workshop and the Requirements Definition Review are scheduled for late in the year. In FY 1996 the BTF experiment control computer wlll be on Mir to control cell and tissue culture experiments. The Mir precursor flights will reduce the risk in the design and development of full facility operations for Space Station. The BTF project will conduct Its Critical Design Review near the end of FY 1996. The current launch readiness date for the BTF is the fourth quarter of 1998.

Fluids/Combustion Facility

In FY 1994, the FCF completed Phase A studies on the fluids module. The precursor to the first facility combustion module entered the design and development phase to be prepared for flight on MSL-1 (FY 1997). The conceptual design for the fluids module for the FCF was held in December 1994. The first combustion module design is based on a Space Shuttle combustion module that will hold its transition review in March 1995. The first international workshop to identify possible cooperative experiment module development in fluid physics and combustion science will be held in April 1995. An independent assessment of the facility will be held in April. The combustion and fluids modules for the FCF will both hold their Requirements Definition Review in December 1995. After successful completion of the review, the facility will proceed to the design and development phase. The current launch readiness date for FCF and the first fluids module is the third quarter of 1999.

Space Station Furnace Facility

Full scale development of the SSFF was initiated in early FY 1994. The facility conducted a successful Preliminary Requirements Review and completed the definition phase for the first two furnace modules. The first International workshop to identify cooperative furnace developments was held with the Space Station International partners in Nordwijk, Holland. The Preliminary Design Review was held for the SSFF core. An independent assessment of the facility was held in September 1994. Agreements will be negotiated with the ESA and the French Space Agency for the development of additional furnace modules for the facility. A second international workshop to further refine cooperative furnace developments is scheduled for February 1995 in Huntsville. Alabama. The SSFF core will be fabricated after the Critical Design Review in December 1996. Modifications to the U.S. Spacelab furnace to allow It to be the first U.S. furnace module in the facility will begin in early 1996. The current launch readiness date for the Core facility and the first instrument rack is June 1999.

EXPRESS Rack Development

In FY 1995 detailed design will be completed and assembly and test will be underway for the initial EXPRESS rack that will be flown on MSL-1. Detailed design will continue for the EXPRESS rack configuration planned to fly on the Space Station. Testing and integration of the MSL 1 EXPRESS rack will be completed in FY 1996. and the rack will be delivered to the KSC for payload integration and launch processing. Design will be completed for the Space Station EXPRESS rack configurations and assembly of hardware will be underway for qualification and acceptance testing. The delivery date for the EXPRESS rack planned for use on MSL-1 is April 1996. The delivery date of the first Space Station EXPRESS rack is February 1998.

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATE8

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995 (Thousand of Dollars)	FY 1996	page Number
Earth observing system	392,876	591.100	591.100	SAT 3-5
Earth observing system data information system	188,158	230,600	289.800	SAT 3-15
Earth probes	96,426	81,600	36.900	SAT 4-19
Payload and instrument development	25,900	19,500	4.900	SAT 3-22
Applied research and data analysis	317,140	344,300	308.400	SAT 3-25
Global observations to benefit the environment	[300]	5,000	5,000	SAT 3-40
Advanced communications technology satellite	3,000	2,300	--	SAT 3-42
Launch services	26,500	48,700	88,000	SAT 3-43
Construction of facilities	18,000	17,000	17.000	SAT 3-45
(Earth systems science building)	(12,000)	(17,000)	(17,000)	
(Langley Research Center distributed active archive center)	(6,000)	(--)	(--)	
To	1,068,000	1.340.100	1.341.100	

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Distribution of Program Amount bv Installation			
Johnson Space Center	167	--	--
Kennedy Space Center	75	100	100
Marshall Space Flight Center	12,904	8,600	9.600
Stennis Space Center	80	500	400
Ames Research Center	37,723	37,400	33.900
Langley Research Center	31,720	60.600	48.800
Lewis Research Center	19,103	40,600	66.300
Goddard Space Flight Center	747.075	836,000	883.400
Jet Propulsion Laboratory	105,055	204,900	157.100
Headquarte	114.098	151.400	141.500
To	1.068.000	1.340100	1.341.100

OFFICE OF MISSION TO PLANET EARTH

PROGRAM GOALS

The overall goal of the Mission to Planet Earth (MTPE) program is to understand the total Earth system and the effects of natural and human-induced changes on the global environment. To preserve and improve the Earth's environment for future generations, people around the world need to base policies and decisions on the strongest possible scientific understanding. The vantage point of space provides information about the Earth's land, atmosphere, ice, oceans, and biota that is obtainable in no other way. In concert with the global research community, the MTPE program is utilizing space to lead the development of knowledge required to support the complex national and international environmental policy decisions that lie ahead. The MTPE Earth Observing System (EOS) will establish the foundation for a new, innovative approach to global environmental monitoring and climate prediction. The outcome of MTPEs policy-relevant, global environmental science focus will help to insure a strategic advantage for American enterprise.

STRATEGY FOR ACHIEVING GOALS

The scientific discipline associated with MTPE's activities is Earth system science, which has strong elements in the atmospheric, oceanic. hydrological, ecological, and solid Earth sciences but integrates them in a way that the full range of couplings in the Earth system can be addressed. Earth system science is a young discipline. and MTPE investigators and programs make a significant contribution to its emergence as a field of scientific endeavor. The collection of global data to characterize the Earth system is a cornerstone of the MTPE program. Comprehensive measurements are being made covering the land. atmosphere. ice. bodies of water, and biota. Data must be collected for extended periods of time due to the long time constants associated with the changing Earth system. Future data will be integrated with previously obtained data to enable study of the long-term evolution of the Earth system. The MTPE program is strongly committed to analysis and interpretation of archived data. Data gathering and analysis will be accompanied by theoretical and modeling efforts which provide the framework for the interpretation of data and for quantitatively testing our understanding of how the Earth system works.

The MTPE program develops Earth observing spacecraft and instruments, acquires data, and disseminates these data, information. and scientific understanding throughout the world. Along with predictions, data and information from the MTPE program form the basis for decision-making on complex, environmental policies. NASA brings to the field of Earth system science the ability to observe the Earth globally from space. The MTPE program provides the space-based assets, complimentary aircraft, balloons and in-situ capabilities, and the scientific capabilities to interpret the data for modeling, prediction, and assessment needs. Resultant data, information, and scientific understanding must be provided to all classes of users, including but not limited to the Earth science community. Policy makers, environmental decision-makers and resource managers, industrial planners, social scientists

and the general academic community, educators, and interested individuals must have effective access to Earth science data and ideas so that difficult decisions about managing the global environment can be made on an informed basis.

MTPE products form the basis for public education, as well as for training future generations of scientists and engineers. Communication to the general public is important so that people can effectively participate in the national decision making process and can understand the complex economic and environmental tradeoffs that may be required. Training of future generations of Earth scientists, fully representing the diversity of the United States, is inspired and facilitated by the data and ideas developed by the MTPE.

The MTPE program contributes directly to American economic growth and competitiveness through the scientific products we deliver as well as by developing and infusing spacecraft instrument and information system technologies to enable new scientific investigations. Methods used by MTPE to obtain, interpret, and distribute Earth system data and information must be cost-effective and be at the cutting edge of science and technology. The MTPE utilizes technology that is currently available and works to develop and infuse needed new technologies. MTPE investigators work to develop technologies and products that have multiple uses including those which will help ensure continued economic competitiveness for the United States. People are benefiting today from MTPE products. This includes farmers, foresters, fishermen, land-use managers, etc.. who currently utilize the weather prediction and remote sensing capabilities. Global environment is playing an increasing role in global business. Leading the international efforton global environment helps ensure a level playing field for enterprise.

The MTPE program consists of the Earth Observing System (EOS), the EOS Data Information System (EOSDIS).a series of Earth probe satellites, additional payloads flown on the Space Shuttle, specialized aircraft and balloons, and a focused scientific investigation program that provides the scientific understanding necessary to accomplish the MTPE goals.

Upcoming activities over the next two years in the Mission to Planet Earth program include. in the Earth probes program, launch of the first Total Ozone Mapping Spectrometer (TOMS)Earth probe in FY 1995, and launch of the NASA Scatterometer and TOMS instrument on the Japanese Advanced Earth Observing System (ADEOS)spacecraft in FY 1996. Launch of the Ocean Color Mission is also expected in FY 1995. The mission operations and data analysis program within MTPE will begin operations of the Earth probes satellites and processing of the data received from them and the Ocean Color Mission, in addition to maintaining activities for currently orbiting satellites and recently completed space shuttle missions. The instrument and payloads development program will be focused on Shuttle Imaging Radar-C (SIR-C)and Atmospheric Laboratory for Applications and Science (ATLAS-3)post-mission activities. Within the Earth Observing System, critical design reviews will be held for the AM-1 spacecraft and Landsat-7 spacecraft in FY 1995. and for the SeaWinds spacecraft in FY 1996. The EOSDIS will release Version 1 FY 1996, and prepare for the release of Version 2.

BASIS OF FY 1996 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
AM series	198,759	260,800	202,200
PM series	50,100	88,800	127,300
Chemistry	2,200	10,300	27,700
Special spacecraft	20,925	85,500	69,700
(Space station attached payload - SAGE III	(--)	(--)	(4,100)
Algorithm development..	46,792	58,300	85,400
Landsat-7.	74,100	87,400	78,800
*Total	392,876	591,100	591.1'00

* Total cost information is provided in the Special Issues section

PROGRAM GOALS

The overall goal of the Earth Observing System (EOS) is to advance the understanding of the entire Earth system on a global scale by improving our knowledge of the components of the system, the interactions between them, and how the Earth system is changing. The EOS will study the atmosphere, oceans, cryosphere, biosphere, land surface and solid Earth, particularly as their interrelationships are manifested in the flow of energy and in the cycling of water and other chemicals through the Earth system.

The EOS program mission goals are: (1) To create an integrated, scientific observing system emphasizing climate change, that will enable multidisciplinary study of the Earth's critical, life-enabling, interrelated processes: (2) To develop a comprehensive data and information system, including a data retrieval and processing system: (3) To serve the needs of scientists performing an integrated multidisciplinary study of planet Earth and to make MTPE data and information publicly available: and, (4) To acquire and assemble a global database for remote sensing measurements from space over a decade or more to enable definitive and conclusive studies of Earth system attributes.

STRATEGY FOR ACHIEVING GOALS

The EOS contributes directly to accomplishing the goal of understanding global climate by providing a combination of observations made by scientific instruments, which will be integrated with the EOS spacecraft, and the data received, archived, processed, and distributed by the Earth Observing System Data Information System (EOSDIS). The selection of scientific priorities and data

products responds directly to the United States Global Change Research Program global change science priorities and the Intergovernmental Panel on Climate Change's (IPCC) assessment of the scientific uncertainty associated with global change.

The three main EOS spacecraft that will support observations by the scientific instruments include the morning (AM). afternoon (PM), and Chemistry series. Beginning in 1998.2000, and 2002 respectively, a satellite in each series will be flown for a period of six years in order to obtain, at a minimum, a data set that will span fifteen years. Additional observations will be provided by the Landsat-7 mission in 1998. Data continuity for the Landsat program will be maintained by flying an advanced technology Landsat instrument on the AM-2 mission in 2004. Within the special spacecraft program, flight of the Altimetry-Radar and Altimetry-Laser satellites, as well as the SAGE-111, SeaWinds, ACRIM. Ocean Color, and CERES instruments will depend on a combination of domestic and international participation by the Japanese. Europeans, and Russians.

International participation is a highly valued element of the EOS program. Understanding global climate requires a global effort. In addition to the fiscal benefits from integrating our complimentary science programs, it is critical to ensure that the world's decision makers have a common body of information that is credible and well-understood.

EOS program planning began in 1983 with the definition of the science and mission requirements by the EOS Science and Mission Requirements Working Group (SMRWG). The SMRWG charter was to examine the major Earth science questions for the 1990's and to define the requirements for low-Earth-orbit observations needed to answer these questions on a comprehensive multidisciplinaxy basis. The SMRWG's report, issued in 1984, listed five basic recommendations concerning Earth science in the 1990's:

- A program must be initiated to ensure that the present time series of Earth science data are maintained and continued. Collection of new data sets should be initiated.
- A data system that provides easy, integrated, and complete access to past, present, and future data must be developed as soon as possible.
- A long-term research effort must be sustained to study and understand these time series of Earth observations.
- The EOS program should establish an information system to carry out those aspects of the recommendations that go beyond existing and currently planned activities.
- The scientific direction of EOS should be established and continued through an International Scientific Steering Committee.

The Earth System Sciences Committee (ESSC) was appointed in November 1983 by the NASA Advisory Council to consider directions for NASA's Earth-sciences program. The committee's report, issued in May 1986, recognized EOS as the centerpiece of the future Earth sciences implementation strategy. It stated the following goal of Earth system science: 'To obtain a scientific understanding of the entire Earth system on a global scale by describing how its component parts and their interactions have

evolved. how they function. and how they may be expected to continue to evolve on all time scales." It also identified the following challenge to Earth system science: "To develop the capability to predict those changes that will occur in the next decade to century, both naturally and in response to human activity."

The successor to the SMRWG, the EOS Science Steering Committee (SSC), continued the definition of the EOS program and provided an overall implementation strategy in its report issued in 1987. Concurrent with the SSC work, NASA included the EOS program under a broader Agency initiative termed Mission to Planet Earth (MTPE), which included other efforts such as the Earth Probe Missions and NASA's participation in the International Geosphere Biosphere Program (IGBP) and the World Climate Research Program (WCRP). By proceeding to carry out the recommendations of the SMRWG and the ESSC, including EOS, the SSC argued that it would be possible to move from a single-discipline research mission to a comprehensive mission addressing all aspects of the Earth as a system. Thus, the concept of an Earth system was adopted as the EOS scientific thrust.

An Announcement of Opportunity (AO) to solicit proposals for EOS investigations was issued in January 1988. The EOS program objectives were based on the requirements and goals of the SMRWG, SSC, and ESSC. In responding to the AO, proposers could offer to do Interdisciplinary (ID) studies to carry out integrated Earth system research leading to the development of comprehensive Earth system models, to be members of research facility teams (formed to provide scientific guidance for the development of the research Facility Instruments (FI's) and to analyze and interpret data from them). or to be Principal Investigators (PI's) of proposed instruments and data products. The EOS selection process was completed in February 1989, with the selection of six Team Leaders (TL's) and 93 Team Members (TM's) for the 6 NASA research FI's, 24 Instrument PI's, and 29 Interdisciplinary Team PI Leaders to participate in the definition phase of the EOS program.

The EOS Investigators Working Group (IWG), formed in 1989, consists of PI's (Instrument and Interdisciplinary), and TL's to provide scientific advice and guidance for the program. The program scientist (from NASA Headquarters) and the senior project scientist (from GSFC) co-chair the IWG. The working bodies of the IWG include twelve science panels. The chairpersons of each of these panels. together with the program scientist and senior project scientist, constitute the Science Executive Committee (SEC) of the IWG. Membership on the panels is generally open to all EOS investigators. including co-investigators on any EOS investigation and members of EOS FI teams. Scientists outside the group of EOS investigators are also included in the various panels.

The IWG plays a leading role in defining the overall science thrust for the EOS program. It coordinates the research efforts and provides guidance and advice to the EOS program and project. as appropriate. concerning all major scientific issues. It will meet regularly throughout the lifetime of the program.

The EOS study project was established at GSFC in 1983. During the Phase A and B study periods. GSFC and the Jet Propulsion Laboratory (JPL) performed mission. data system and spacecraft studies resulting in a conceptual design of a dual series of spacecraft missions that would satisfy the EOS requirements. The spacecraft were designated EOS-A and EOS-B, with GSFC and JPL having the respective managerial responsibilities. Following the EOS Non-Advocacy Review (NAR), held in June 1989, management responsibilities for the EOS-B series, as well as the project management role for the execution phase of EOS, were transitioned to GSFC. The Synthetic Aperture Radar (SAR), which was an FI to be launched on EOS-B, was identified as an

independent mission, to be managed by JPL. and a candidate for separate program approval. In 1990, responsibility for development of the platform was transferred from the Space Station Program to EOS. EOS management became centralized within the EOS Project at GSFC.

The EOS program was approved by Congress as an FY 1991 budget initiative. The payload for the first flight (EOS-A1) was selected in January 1991. following Conceptual Design and Cost Meows (CDCR's) of the selected instruments and IWG Payload Panel recommendations on scientiflc priorities and synergism. The baseline flight segment consisted of two series of large observatories, EOS-A and-B. in 1:30 PM ascending, sun-synchronous orbit, launched by a Titan-IV with Solid Rocket Motor Upgrades (SRMU's) from the Western Space and Missile Center (WSMC). Each observatory had a 5-year life and each was to be replaced twice to provide a 15-yearmission. The budget runout through FY 2000 was $17 billion.

The National Research Council (NRC) advises the federal government through reports of reviews it conducts using its various committees, which involve the broad community of science and technology experts. Prior to the EOS new start approval in FY 1991, their report, 'The U.S. Global Change Research *Program:* An Assessment of FY 1991 Plans" provided a critical review of the EOS program.

In the July 1991, report. "Assessment of Satellite Earth Observation Programs 1991." the *NRC* was in general agreement with the EOS plan for the large EOS-A observatory and its selected payloads. It expressed concern that the total EOS budget size could lead to potential delays, noted data gaps in key areas, and endorsed the MTPE Earth probe concept. These reviews were the beginning of a series of reviews and evaluations of the program to ensure the proper scientific return on the EOS investment.

As part of the FY 1992 budget process, the Committees on Appropriations directed NASA to restructure the EOS program to:

- Focus the science objectives of EOS on the most important problem of global change (i.e., global climate change).
- Increase the resilience and flexibility of EOS by flying the instruments on multiple. smaller platforms rather than a series of large platforms.
- Reduce the cost of EOS through FY 2000 to $11 billion.

In the summer and fall of 1991. NASA conducted a restructuring of the program to meet the Congressional mandate. This process included an independent review by the External Engineering Review Committee. which issued its report in September 1991. The process also involved assessment by the scientists who will use the data from EOS, including both the EOS IWG and the EOS Payload Advisory Panel. The EOS project at GSFC conducted studies to determine how the EOS instruments could most effectively be configured on small spacecraft. In December 1991, the NASA Administrator reviewed and approved the restructured EOS program. and in March 1992, NASA submitted its report on the restructured program to Congress. Congress approved the restructured program in 1992.

Recognizing that the subsequent budget environment would not support the complete and timely implementation of the restructured EOS program described in the March 1992, report to Congress, the NASA Administrator directed that the Program be rescoped with a goal of further reducing its costs through FY 2000 by 30 percent to $8 billion. The EOS reassessment was completed in June 1992, satisfying the 30 percent reduction by capitalizing on efficiencies, reducing at-launch science data products, by rephasing work, by increasing international participation. and by deleting the High-Resolution Imaging Spectrometer (HIFUS) flight instrument.

In the 1995 Congressional budget cycle, the EOS budget was reduced by $758.5 million through FY 2000. $7,243.4 million of which $131.3 million was due to a funding responsibility transfer. The past year has been spent fully defining a program that would satisfy the principle objectives within the constrained funding profile. The EOS rebaselining effort. with the following results, is reflected in this budget submission.

- Preserve the scientific Integrity of EOS and Mission to Planet Earth.
- Preserve the measurement complement of the first mission in each series.
- Preserve the launch dates for AM-1, PM-1 and Chemistry-1.
- Phase EOSDIS development to support missions through FY 2000.
- Restore reserves to a prudent level.
- Incorporate appropriate technology advancements.
- Fit within annual funding guidelines for the EOS program.
- Replace major spacecraft at six year intervals.

Public Law 102-555 returned the development, operations and data distribution of the Landsat-7 program to the federal government in 1992. It established the Landsat Program Management (LPM) team comprised of the Department of Defense (DOD) and NASA. DOD was responsible for the acquisition of the satellite and NASA was responsible for the development of the ground system. In the fall of 1993, DOD withdrew from the program. At the direction of the National Science and Technology Council (NSTC), the Office of Science and Technology (OSTP) initiated a review and restructuring of the Landsat-7 Program. Under Presidential Decision Directive (PDD)/NSTC-3, the Land Remote Sensing Strategy was established. This strategy implemented a program management structure for the Landsat-7 Program. which made NASA responsible for development of the satellite. instrument and ground system, National Oceanic and Atmospheric Administration (NOAA) responsible for operations, and the U.S. Geological Survey (USGS), in conjunction with the EOSDIS Land Process Distributed Active Archive Center (LPDAAC). responsible for data archive and distribution. During the EOS rebaseling process, the Landsat-7 program was integrated with EOS.

The EOS science has been reorganized. The funding to support the activities of the EOS instrument investigators and interdisciplinary science investigators has been moved to research and analysis. The science algorithm development and maintenance remains in the EOS budget.

Within NASA, GSFC is responsible for development and operation of the EOS remote sensing spacecraft. instruments (whether at GSFC or other NASA centers), and data and information system for the conduct of Earth science investigations using the data from all Earth-obseming sources. An MTPE Office has been established within the Office of the Director at GSFC to provide overall management, guidance, and coordination of the EOS activities.

AM Series

The global climate change research emphasized by the AM instrument data set will include cloud physics, atmospheric radiation properties, and terrestrial and oceanic characteristics. Because the AM series primarily observes terrestrial surface features, a morning equatorial crossing time is preferred to minimize cloud cover over land. The primary contractors associated with the program are Martin Marietta Astro Space (MMAS) for the AM-1 spacecraft, Hughes Santa Barbara Research Center (SBRC) for the Moderate Resolution Imaging Spectrometer (MODIS) instrument, TRW for the Clouds and Earth's Radiant Energy System (CERES) instrument, (the instrument will also be flown on the TRMM and PM Series spacecraft, and as a flight of opportunity). and Martin Marietta for the AM-1 Atlas Centaur/IIAS launch service. The Multi-Angle Imaging Spectrometer (MISR) instrument is being built in-house at JPL and the Earth Observing Scanning Polarimeter (EOSP) instrument for AM-2 is being built in-house at the Goddard Space Flight Center (GSFC). The Japanese will be providing the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument and the Canadians the Measurement of Pollution in the Troposphere (MOPITT) instrument for the AM-1 spacecraft.

PM Series

The PM series will focus on atmospheric temperatures and humidity profiles, clouds, precipitation. and radiative balance: terrestrial snow and sea ice: sea-surface temperature and ocean productivity: soil moisture: and the improvement of numerical weather prediction. With the emphasis of the instrument complement being cloud formation, precipitation, and radiative properties. an afternoon equatorial crossing is more suitable for acquiring the data. The primary contractors associated with the program are LORAL, in conjunction with JPL, for the Atmospheric Infrared Sounder (AIRS) instrument, and Aerojet General Corporation for the Advanced Microwave Sounding Unit (AMSU-A) instrument. The European Space Agency will be providing the MIMR instrument for the PM-1 spacecraft.

Chemistry Series

The Chemistry series will study atmospheric chemical species and their transformations. The Tropospheric Emission Spectrometer (TES) and the Microwave Limb Sounder (MLS) instruments are being built in-house at JPL. The Japanese will be providing the Chemistry International Instrument (CII) and the United Kingdom will be providing the High Resolution Dynamics Limb Sounder (HIRDLS) instrument for the Chemistry-1 spacecraft.

Special Spacecraft

The Special Spacecraft will study atmospheric aerosols, ocean circulation, ice-sheet mass balance, ocean biomass and productivity. cloud physics, atmospheric radiation properties, ocean surface stress, and lightning. Ball Aerospace is responsible for developing the Stratospheric Aerosol and Gas Experiment (SAGE-111) that will fly on the Space Station and will take advantage of both solar and lunar occultations to measure aerosol and gaseous constituents of the atmosphere. The Russians will support flying a SAGE-I11 instrument in 1998 and another SAGE III will fly aboard the Space Station in 2000. The Japanese will be providing their Advanced Earth Observing System 11 (ADEOS 11) spacecraft for the SeaWinds instrument. Depending on the outcome of the evaluation of each party's proposal, either the Navy or CNES will be a participant in flying the first Altimetry Radar mission. There remain a number of instruments in the Special Flights Program that are also identified as flights of opportunity (i.e. Ocean Color, SOLSTICE, and CERES). It has been assumed under the recent EOS rebaselining that these instruments will fly on an as yet undetermined domestic or foreign mission.

Landsat

The Landsat Program will continue to provide substantially cloud-free, sun-lit land surface imagery for detecting and characterizing regional and global change. The primary contractors are MMAS for the Landsat-7 spacecraft, SBRC for the Enhanced Thematic Mapper Plus (ETM+), and McDonald Douglas for the Landsat-7 Delta 2 launch service. NOM will be responsible for operating the satellite and the USGS will archive the data.

MEASURES OF PERFORMANCE

Preliminary Design Reviews: PM-1 April 197 Chemistry-1 March 1998 SeaWinds May 1995	Confirms that the proposed project baseline is comprehensive (meets all program-level performance requirements), systematic (all subsystem/component allocations are optimally distributed across the system), efficient (all components relate to a parent requirement). and represents acceptable risk.
Critical Design Reviews: AM-1 January 1995 PM-1 April 1998 EOS Chemistry-1 June 1999 SeaWinds December 1995 Landsat-7 September 1995	Confirms that the project system, subsystem, and component designs, derived from the preliminary design. is of sufficient detail to allow for orderly hardware and software manufacturing, integration, and testing. and represents acceptable risk. Successful completion of the critical design review freezes the design prior to actual development.

Instruments Delivered: AM-1 Last Instr. February 1997 PM-1 Last Instr. December 1998 Landsat-7 December 1996 Aerosol SAGE-I11 (Russian) December 1997 SeaWinds March 1998	Confirms that the fabrication, integration, certification, and testing of all system hardware and software conforms with their requirements and is ready for recurring operation. Throughout system development, testing procedures or, as appropriate, engineering analysis have been employed at every level of system synthesis in order to assure that the fabricated system components will meet their requirements.
Algorithm Development (Version 2): EOS AM-1 June 1997 EOS PM-1 December 1999 Chemistry-1 December 2001 Aerosol SAGE-I11 (Russian) December 1997 Altimetry Radar-1 December 1998 Altimetry Laser-1 July 2002	Confirms that the second version of the science software necessary for the production of the standard data products for each mission has been developed and is ready to support launch.
Launch Readiness Date: AM-1 June 1998 PM-1 December 2000 Chemistry-1 December 2002 Landsat-7 December 1998 Aerosol SAGE-111 (Russian) December 1998 Altimetry Radar-1 December 1999 Altimetry Laser-1 July 2003	Verifies that the system elements constructed for use, and the existing support elements, such as the launch site, space vehicle and booster, are ready for launch.

ACCOMPLISHMENTS AND PLANS

During FY 1994, the AM-1 entered its Critical Design Review (CDR) phase. The U.S.-supplied instruments began CDR with the Clouds and the Earth's Radiant Energy System (CERES) in December 1993, followed by the Moderate-Resolution Imaging Spectrometer (MODIS) in 1994. The spacecraft component and subsystem CDR's and the AM-1 launch vehicle selection were conducted during the third quarter of FY 1994. These activities will lead to the system-level AM-1 CDR in FY 1995.

Phase B studies of the PM-1/Chemistry-1/AM-2 common spacecraft observatories were extended in FY 1994 in order to consider alternative configurations that would allow for the use of a medium-sized launch vehicle. The extended studies came to a successful close with the Request For Proposal (RFP) released in August 1994. Activity on the instruments include the continuation of Phase B studies, particularly the Microwave Limb Sounder (MLS), which is considered a technologically demanding effort. Notable progress has been achieved on the cooler development in support of the Atmospheric Infrared Sounder (AIRS)

instrument, and successful demonstrations at more than one cooler vendor were conducted during FY 1994. Other activities include a search for an alternative source for the Microwave Humidity Sounder (MHS) or equivalent instrument (originally to be provided by an international partner).

Algorithm activity, especially within the AM-1 program, included progress in defining the standard data products to be produced by EOS. A baseline set is now currently documented within the EOS Project Plan, and was verified by the investigators in FY 1994. The algorithms, which interpret the radiance data into geophysical parameters, entered the early design stage, paced by design maturity of the instruments and the delivery of the product generation system tool kits from EOS Data Information System (EOSDIS). During FY 1994, the MTPE program had significant changes made to its involvement with the Landsat-7 program. In addition to supporting the in-house ground system development, NASA has now assumed responsibility from the DOD to acquire the Landsat spacecraft and ETM+ instrument. Responsibility for Landsat operations will be assumed by NOAA, while data archiving and distribution through the EOSDIS will be carried out by the USGS. A joint management plan with NOAA and the USGS was signed in August 1994, establishing responsibilities of each partner agency, and the Landsat data policy was signed by NASA, NOAA and USGS in 1994.

Most activity during FY 1995 will be concentrated on the final design of the AM-1 spacecraft, the flight of opportunity instruments, and the science algorithms. On AM-1, NASA will complete the CDRs for the spacecraft subsystems and instruments, so final designs can be verified at the system-level CDR in the second quarter of FY 1995. Also in FY 1995, the flight software CDR will be completed. In FY 1995, assembly of subsystem components will be completed for the power, electrical, thermal control, guidance, and navigation. NASA will test the subsystems in preparation for spacecraft integration and test in FY 1996. The flight units of two of the U.S.-made instruments (MODIS and CERES) will also complete assembly and test. Calibration of the engineering model of Multi-Angle Imaging Spectrometer (MISR), the third U.S. instrument, will be accomplished, and parts for the protoflight unit will be procured. Phase B and preliminary design activities will continue on the instruments planned for the PM-1 and Chemistry flights.

Two EOS flight of opportunity instruments will be delivered to the Tropical Rainfall Measuring Mission (TRMM) in FY 1995, the protoflight unit for CERES and the Lightning Imaging Sensor (LIS). A third flight of opportunity instrument, SeaWinds (formerly called NASA Scatterometer II) will complete instrument subsystem (i.e., antenna, power supply) CDRs in preparation for the instrument CDR in FY 1996, for delivery to the Japanese Advanced Earth Observing System II (ADEOS II).

The AM-1 science teams will deliver the preliminary "beta" version of the science algorithms to the EOSDIS. In addition to the funds appropriated to NASA in FY 1995, the DoD has been directed by Congress to transfer $25 million to NASA for the Landsat program. In FY 1995, the Landsat-7 spacecraft completed a Preliminary Design Review (PDR) and has a Critical Design Review (CDR) planned for the third quarter. A system requirement review (SRR) for the ground system is also planned for 1995.

Funding is needed in FY 1996 to support integration and test of the spacecraft and instruments for AM-1, award of the common spacecraft contract, and fabrication of several flight of opportunity instruments. On AM-1, all subsystems for the spacecraft will be

completed and integrated in FY 1996. Instrument delivery for integration on the spacecraft will begin with the MODIS instrument in early 1996, followed by ASTER, CERES, MOPITT. and MISR. Version 1 of the AM-1 science algorithms will also be completed in FY 1996.

With the contract for the common spacecraft awarded in FY 1995, the PM-1 spacecraft will be undergoing a thorough evaluation of its subsystem and system level designs in preparation for the Preliminary Design Review in early FY 1997.

Within the EOS flights of opportunity, the engineering model for the SeaWinds instrument will undergo integration and test during FY 1996. The engineering and protoflight model for the SAGE-I11 instrument will be in development phase during FY 1996.

Version 2 of the science software needed for the EOS instruments on the TRMM mission will be completed in FY 1996 in support for the mission launch in 1997.

In FY 1996. the instrument will be delivered and spacecraft integration begun, with the ground system CDR to occur during the first quarter of the year.

BASIS OF FY 1996 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
*Earth observing system data information system	188,158	230,600	289,800

• Total cost information is provided in the Special Issues section

PROGRAM GOALS

The goals for the EOS Data and Information System (EOSDIS)are the development and operation of a highly integrated system which can produce the data and information products from the EOS, to preserve these and all other Mission to Planet Earth environmental observations for continuing use, and to make all these data and information easily available for use by the research. education, government agencies and all those who can benefit from them in making economic and policy decisions. The EOSDIS is critical to achieving the goals of Mission to Planet Earth by enabling the public to benefit fully from our increased understanding and observations of the environment.

STRATEGY FOR ACHIEVING GOALS

EOSDIS provides data archive and distribution for all Mission to Planet Earth data and information. All EOS instrument data and information products will be processed and distributed by the EOSDIS system. The command and control of the EOS spacecraft and instruments is part of EOSDIS.

By making available NASA's current data and information from Mission to Planet Earth program today, the research community and the public are served by EOSDIS. This is being accomplished through an initial version of the system, implemented at nine Distributed Active Archive Centers (DAAC)and through cooperative efforts with NOAA, the USGS, and international partner space agencies. Major development of the next two versions of the system are under way to improve service to users, incorporate new technologies, and prepare for the first flights of EOS instruments in 1997 and the EOS AM-1 spacecraft in 1998. The EOSDIS is employing an evolutionary design to enable adaptation to changes in user needs and technology. The design is also modular allowing the replacement of individual components without costly overall system changes or disruptions in service.

NASA is making extensive use of prototypes to assure that EOSDIS will effectively meet the needs of the satellites and users. A limited amount of technology development and adaptation is focused specifically on meeting EOSDIS evolutionary needs while relying on other programs at NASA and other agencies to fund needed technology development efforts of a more generic nature. The development of pathfinder data sets using currently available data to produce long-term records of environmental change continues.

The pathfinder efforts provide better understanding of the processes involved in production of such products while supporting on-going research efforts.

The EOSDIS development has been divided into four major components: the EOS Data Operations System (EDOS) developed by TRW, the EOS Communications System (ECOM) developed in-house by GSFC using Computer Sciences Corporation and Allied Signal, the EOSDIS Core System (ECS) developed Hughes Applied Information Systems, and the Distributed Active Archive Centers (DAAC's). The EDOS receives the raw data stream from the satellites, separates the data by instrument. and performs the initial processing and back-up archiving. The ECOM delivers the real time data to and from the operations control centers and the science data to the DAAC's. The ECS includes the flight operations segment, the communications and systems management segment., and the science data processing segment providing satellite and instrument command and control, the hardware and software for data product generation, archival. and distribution, and the systems to integrate all EOSDIS operations. The EOSDIS Independent Verification & Validation (IV&V) contract is with Intermetrics Systems Services Corporation.

The nine DAAC's process the raw data from the satellites into useful products, handle all user product searches, requests. and orders, and distribute data and information directly to the user community via the national information infrastructure and through other means. The DAAC's also permanently archive all Mission to Planet Earth data and information for future use. To better serve the user community, each DAAC focuses on the data needs of a specific segment of the user community. Any user may access the entire Mission to Planet Earth data holdings from any DAAC as well as gaining access to affiliated systems at other agencies nationally and internationally. Each DAAC is guided by a users working group.

The nine DAAC's are:

- Alaska Synthetic Aperture Radar (SAR) Facility, University of Alaska Geophysical Institute. Fairbanks, Alaska
- Earth Resources Observation System (EROS) Data Center, U.S. Geological Survey, Sioux Falls, South Dakota
- Goddard Space Flight Center, Greenbelt, Maryland
- Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
- Langley Research Center, Hampton. Virginia
- Marshall Space Flight Center, University of Alabama at Huntsville, Alabama
- National Snow and Ice Data Center, University of Colorado. Boulder, Colorado
- Oak Ridge National Laboratory, U. S. Department of Energy. Oak Ridge, Tennessee

- Socio-Economic Data and Application Center, Consortium for International Earth Science Information Network (CIESIN), Saginaw. Michigan

The EOSDIS Version 0 allows direct access to some data holdings from the United States Geological Survey and National Oceanic and Atmospheric Administration. Relationships with Canada, Japan, and several European countries have been established for the exchange of data for EOSDIS. Many multi-agency efforts, in addition to the NASA EOSDIS, make environmental data available to the public, especially in the Interagency Working Group on Data Management for Global Change and the Federal Geographic Data Committee. The agencies include the United States Geological Survey, Department of Energy, National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the United States Department of Agriculture, the Department of Defense, the Department of the Interior, and the White House.

MEASURES OF PERFORMANCE

Release Version 0 August 31, 1994	Support the design and development of EOSDIS Version 1
EOSDIS Version 1 February 1996	Support the launch of the Tropical Rainfall Measuring Mission
EOSDIS Version 2 November 1997	Support the launch of the AM-1 mission
EOSDIS Version 3 December 1999	Support the launch of the PM-1 mission

ACCOMPLISHMENTS AND PLANS

To demonstrate the basic EOSDIS design concepts prior to the award of the major contracts, a prototype EOSDIS system (Version 0) has been developed. Version 0 was released to the public on August 31, 1994. Version 0 links to all of the DAAC's except the Consortium for International Earth Science Information Network (CIESIN). The Version 0 includes basic interoperability protocols to allow users to search and retrieve data from multiple DAAC's. Version 0 also links to a NOAA and a USGS system. Basic functions include: data searching across DAAC's, product generation, browse functions, and a graphical user interface. Version 0 offers the first Earth science view of aggregate DAAC holdings. Several of the DAAC's inherited existing, on-line data systems. Version 0 can successfully navigate fourteen of these heritage data systems. The DAAC's have already begun migrating the contents of these systems into the EOSDIS. A pathfinder program reprocesses old data from NOAA, DOD, and NASA instruments into long term global and regional data sets. The lessons learned from Version 0 development feed directly into the ECS.

The ECS systems design review was held in June 1994. Three tool Mts were released to aid the scientists to integrate their product algorithms into the DAAC's. Three engineering packages (i.e., prototypes) were also released to demonstrate and test certain interoperability aspects of the EOSDIS design.

The ECS preliminary design review will take place in the second quarter of FY 1995. Also in FY 1995, the Version 0 and CIESIN will be linked, and another engineering package and tool kit will be released. Most ECS activities lead to the release of Version 1 but some support Version 2. A systems requirements review for Version 2 will occur in the second quarter of FY 1995. Except for Version 0, the releases of EOSDIS have been timed to support the launches of major EOS satellites.

The release of EOSDIS Version 1 in February 1996, will support the launch of the Tropical Rainfall Measuring Mission (TRMM) in August 1997. TRMM will produce an order of magnitude more data than that currently handled by Version 0. The second half of FY 1996 will focus on test and integration between the TRMM and EOSDIS. Throughout FY 1996, preparation for the release of Version 2 will continue.

BASIS OF FY 1996 FUNDING REQUIREMENT

EARTH PROBES

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
NASA scatterometer	17,095	15,400	3,900
Total ozone mapping spectrometer	13,805	14,900	8.500
Tropical rainfall measuring mission	65.526	51.300	24.500
Total	96.426	81.600	36.900

- Total cost information is provided in the Special Issues section

PROGRAM GOALS

The Earth probes program is the component of Mission to Planet Earth that addresses specific, highly-focused mission requirements in Earth science research. The program was designed to have the flexibility to take advantage of unique opportunities presented by international cooperative effortsor technical innovation. and to complement the Earth Observing System by providing the ability to investigate processes that require special orbits or have unique requirements. The currently approved Earth probes are the Total Ozone Mapping Spectrometer (TOMS), NASA Scatterometer (NSCAT).and Tropical Rainfall Measuring Mission (TRMM).

STRATEGY FOR ACHIEVING

NSCAT

Because winds are a critical factor in determining regional weather patterns and global climate, the NASA Scatterometer (NSCAT) has been developed to measure near-surface wind speeds and directions over the global oceans every two days, under all weather and cloud conditions. The NSCAT data will be useful for both oceanography and meteorology, and will permit the first global study of the influence of winds on ocean circulation, providing data on the effects of the oceans on the atmosphere and improved marine forecasting on winds and waves. The lead Center for this program is JPL, and the main contractor for the instrument development is the Harris Corporation.

When NSCAT was first initiated in October 1984, it was planned for launch aboard the Navy Remote Sensing Satellite (N-ROSS). After final cancellation of N-ROSS in March 1988, NSCAT was selected in August 1989, for flight on the Japanese Advanced Earth Observing System (ADEOS). Since a majority of the instrument design had been completed during the period that NSCAT was to fly on N-ROSS, the past few years of the program have centered on making design changes to the instrument so that it can be accommodated on the ADEOS spacecraft and completing the instrument. The NSCAT launch is planned for February 1996.

TOMS

The TOMS program will continue the high-resolution global mapping of total atmospheric ozone concentrations on a daily basis. The scientific objectives are to measure the long-term changes in total ozone and to verify the chemical models of the stratosphere used to predict future trends. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument (Flight Model 1) on Nimbus-7 and continues with the TOMS instrument (Flight Model 2) on the Russian Meteor-3, launched in 1991. As with the earlier developments. GSFC has the responsibility for flight project development, and post-launch mission operations and data analysis. Prime contractors are Orbital Sciences Corporation (OSC) for the TOMS instruments and Pegasus launch services, and TRW for the TOMS Earth Probes spacecraft. The TOMS program consists of a set of instruments (Flight Models 3.4. and 5, designated FM-3, FM-4. and FM-5) and one spacecraft for launch on a Pegasus expendable launch vehicle in mid FY 1995 (FM-3). The FM-4 is planned for launch on the Japanese ADEOS satellite in February 1996. The FM-5 will be completed in 1995 and is planned for a cooperative mission with Russia in the year 2000.

TRMM

The latent heat released during precipitation is a significant factor in the large-scale computer models used to predict weather and climate change, yet two-thirds of the global rainfall occurs over the tropics where ground-based rain measurements are scarce. The TFMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. In addition, TFMM will provide precise estimates of the vertical distribution of latent heat in the atmosphere. The TRMM data will be used to understand the ocean-atmosphere coupling, especially in the development of El Niño events, which form in the tropics but whose effects are felt globally, causing floods in some areas, yet droughts in others. GSFC has the responsibility for flight project development, and post-launch mission operations and data analysis. The contractors for the instruments are Hughes Santa Barbara Research Center for the Visible and Infrared Scanner (VIRS), and Hughes Space and Communications for the TRMM Microwave Imager (TMI). The TRMM Phase A study was completed in July 1988. and Phase B completed in February 1991. Award of major contracts began in May 1992.

Japan (NASDA) is an active partner with all three Earth Probes, providing the ADEOS spacecraft and H-II launch vehicle for the TOMS (FM-4) and NSCAT, and the Precipitation Radar instrument and H-II launch vehicle for TRMM. Russia will also be a critical partner for the last of the three TOMS Earth Probes missions, providing the Meteor-3 spacecraft and launch vehicle.

In house NASA studies and planning for new technology Earth probes will begin in FY 1996. The goal of the new technology Earth probes is reduction of the weight and cost of future Earth probes thus lowering flight mission costs while improving hardware and software performance capabilities. The goal will be accomplished by establishing access to all technical achievements by industry. academia, and government. covering the cross-cutting technology areas of power and propulsion, materials and structures. operations, robotics, instruments, electronics, and control.

MEASURES OF PERFORMANCE

Launch of TOMS Flight Model 3 July 1995	Pegasus XL/L1011 launch. Turnover of TOMS to the GSFC mission operations and data analysis team expected thirty days after launch, with data calibration and validation completed successfully. Exact date of this launch is dependent upon the successful return to flight of the Pegasus XL/L1011.
Launch of TOMS Flight Model 4 & NSCAT February 1996	Launch as planned aboard the Japanese ADEOS spacecraft and H-11 launch vehicle aboard ADEOS. Turnover of TOMS and NSCAT to the respective mission operations and data analysis teams at GSFC and JPL thirty days after launch, with data callbration and validation completed successfully.
Launch of TRMM August 1997	Launch as planned aboard the Japanese H-11 launch vehicle. with turnover of TRMM operations and data analysis to TRMM ground system and Science Data and Information System (TSDIS) at GSFC thirty days after launch, with data calibration and validation completed successfully.

ACCOMPLISHMENTS AND PLANS

In FY 1994, the TOMS Flight Model 3 and the spacecraft were integrated, tested and prepared for launch. Due to the failure of the Pegasus-XL during the STEP-1 launch attempt on June 27, 1994, the TOMS launch has been delayed until mid-FY 1995. Assembly, test and integration of the TOMS and Scatterometer instruments for ADEOS was completed in preparation for delivery to Japan. Due to delays in signing the ADEOS Memorandum of Understanding (MOU), the TOMS and Scatterometer instrument deliveries were delayed until November 1994. TRMM observatory subsystem and system Critical Design Reviews (CDR's) were completed in FY 1994. The project completed spacecraft flight structural fabrication and assembly. and test program.

NSCAT and TOMS Flight Model 4 instruments are currently undergoing integration and testing in Japan. with the launch date planned for February 1996. Development of the NSCAT science data processing system will continue at JPL. TRMM will complete instrument integration and testing, spacecraft subsystems assembly. test and installation, and begin the observatory integration and testing. The FY 1995 funding plan for TOMS Flight Model 3 assumes launch of the instrument no later than July 1995. If the launch cannot be made by then, an operating plan change will be necessary. If TOMS is launched before the end of July 1995, any available funds will be used to maintain development of the Flight Models 4 and 5.

In FY 1996, TOMS Flight Model 4 and NSCAT will undergo final integration and test aboard the Japanese ADEOS spacecraft, in support of the February 1996, launch. Development of the TOMS Flight Model 5, planned for launch aboard a Russian spacecraft following the ADEOS mission, has proceeded on schedule and is beginning integration and test. Integration and test of the TRMM observatory will continue through FY 1996, along with development of the TRMM science data and information system. Installation of the last instrument, the Japanese Precipitation Radar, and comprehensive performance testing will also be completed in FY 1996.

BASIS OF FY 1996 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Atmospheric payloads	12,062	7,600	1,100
Solid Earth payloads	13,838	11,900	3,800
To	25,900	19,500	4,900

PROGRAM GOALS

The instrument and payloads development program has two parts, the atmospheric payloads program and the solid Earth payloads program. each with its own goals. Together, the two programs provide measurements crucial to the understanding of the role of the Earth's atmosphere and surface during global change. The goals of the atmospheric payloads program are to provide information related to the chemical constituency and dynamics of the Earth's atmosphere, and to provide highly calibrated measurements against which other measurements. particularly satellite data, can be compared. The goal of the solid Earth payloads program is to demonstrate the technology and algorithms needed to make multi-frequency, multi-polarization active radar measurements of the Earth's surface (i.e., land, sea, and ice).

STRATEGY FOR ACHIEVING LS

The Space Shuttle offers a unique capability to undertake short-duration flights of instruments. The Mission to Planet Earth program has incorporated this capability into the Shuttle/Spacelab payload development in these important areas: design, early test, and checkout of remote sensing instruments for long-duration, free-flying missions and short-term atmospheric and environmental data gathering for basic research and analysis where long-term obsemations are impractical. Instrument development activities have supported a wide range of instrumentation, tailored for both Space Shuttle and airborne missions.

Atmospheric Payloads

Within the atmospheric payloads program, the Measurement of Air Pollution from Satellites (MAPS) instrument. which is a gas filter correlation radiometer built at the Langley Research Center (LaRC), has been designed to measure the levels of carbon monoxide in the troposphere and the extent of inter-hemispheric mass transport of carbon monoxide in the lower atmosphere. With its flights aboard the SRL missions. it has provided the first obsemations of the global seasonal variations of carbon monoxide in the Earth's atmosphere.

In addition to supporting the SRL missions, the atmospheric payloads program has been focused on the recent Atmospheric Laboratory for Applications and Science (ATLAS-3)mission. The objective of this mission was to provide a uniquely detailed examination of the middle atmosphere (stratosphere)and its energy input from the Sun, with detailed measurements made for the first time in the Southern Hemisphere in late fall. Measurements of global stratospheric temperatures and trace-gas concentrations were taken, and solar energy emissions and variability were examined. As part of this mission, the following four U.S. instruments were flown: the Active Cavity Radiometer-1 (ACR-1), built at JPL, Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS), built at JPL. the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM),built at the Naval Research Laboratory, and Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument, built at GSFC.

The ACR-1 is designed to aid in the study of the Earth's climate and the physical behavior of the sun by making solar constant measurements. The objective of the ATMOS experiment is to make detailed measurements of gaseous constituents (i.e., hydrogen chloride. water. ammonia, and methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The SUSIM is designed to make very accurate measurements of the sun's ultraviolet radiation, which is the primary sources of energy for the Earth's atmosphere. The SSBUV instrument provides correlative measurements with Solar Backscatter Ultraviolet (SBUV/2) instruments, which fly on NASA and NOM spacecraft, and helps resolve any data reliability problems resulting from calibration drift of those instruments, used to measure the amount and height distribution of ozone in the upper atmosphere.

The Light Direction and Ranging (LIDAR)Atmospheric Sensing Experiment (LASE),built at LaRC, is an advanced technology Earth atmospheric sensing experiment within the atmospheric payloads program. flown aboard the ER-2 aircraft. The objective of this instrument is to obtain water vapor measurements with better resolution and accuracy than current instruments. These measurements will support studies in global hydrology, meteorology, radiation budget, climate and atmospheric transport, and chemistry.

Solid Earth Payloads

Within the solid Earth payloads program, activities have been focused on the development and launch of the Shuttle Imaging Radar-C (SIR-C),which was the primary component of the first and second Shuttle Radar Laboratory (SRL) missions. The SIR-C, in combination with the X-band Synthetic Aperture Radar (X-SAR) contributed by Germany and Italy, is an Earth-imaging. multiple-frequency system that collected data over approximately 50 million square kilometers. The main contractor for the SIR-C radar instrument was Ball Aero Space. Scientists are using the data to make detailed studies of the Earth. including many regions which have not previously been well characterized due to vegetation, cloud. or sediment cover. These radar studies will lead to a understanding of ocean and land surface, and subsurface processes on a global scale.

International cooperation has been notable within the payloads programs. As part of the ATLAS-3 mission, three international instruments were flown: an instrument to measure the solar constant. contributed by Belgium: the Millimeter-wave Atmospheric Sounder. from Germany: and an instrument providing solar spectrum measurements. contributed by France. Germany and Italy have also been major participants of the SRL missions with the contribution of the X-SAR.

MEASURES OF PERFORM

LASE February/July 1995	LASE will be flown again aboard the ER-2 aircraft from Wallops Island, VA and from Houston, Texas.
SRL data records complete September 1997	Data processing of data from two SRL missions and turnover of data to the science teams.
ATLAS data records complete September 1995	Post-mission calibration of ATLAS instruments, data processing and reduction, and closeout of ATLAS activities.

ACCOMPLISHMENTS AND PLANS

Recent missions include the first and second Shuttle Radar Laboratory (SRL) missions flown in April and September 1994. These missions. comprised of the SIR-C and MAPS instruments, were very successful. Nine hundred thirty-five data takes were completed by SIR-C/X-SAR on the last mission, gathering 107 hours of data, while MAPS accumulated 204 hours of data. The ability to make change detection interferometry measurements was successfully demonstrated, correlating measurements from the first to second flights and from repeat shuttle passes.

The Light Direction and Ranging (LIDAR), the In-Space Technology Experiment (LITE) mission, in which the atmospheric payloads program was a contributor. was also flown in September 1994. The ATLAS-3 mission was launched in November 1994. and flew for over 11 days. In September 1994, engineering test flights of LASE were completed at Wallops Island, VA. Data from these flights validated instrument capability and enabled correlative measurements with data from the LITE mission during the shuttle pass over Wallops on September 18, 1994.

Program funding levels within the atmospheric payloads program allow for post-mission calibration of ATLAS instruments, data processing and reduction, and closeout of ATLAS activities. No future flights of ATLAS are planned. LASE will be flown again aboard the ER-2 aircraft from Wallops Island, VA in February 1995. and from Houston, TX in July 1995. Within the solid Earth payloads program, SIR-C data process and reduction will continue.

In FY 1996. SIR-C data processing and reduction will continue at a reduced rate. Remaining closeout activities associated with the ATLAS-3 mission will be conducted.

BASIS OF FY 1996 FUNDING REQUIREMENT

APPLIED RESEARCH AND DATA ANALYSIS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	page Number
MTPE SCIENCE	**200,112**	**227,800**	209,900	SAT 3-26
Research and analysis	174,912	201,800	185.900	
(EOS science included in research and analysis)	(--)	(37.300)	(58.400)	
Airborne science and applications.	25,200	26,000	24.000	
OPERATIONS. DATA RETRIEVAL. AND STORAGE	**117.028**	**116,500**	98,500	SAT 3-33
Mission operations and data analysis	97,644	96,700	82,300	
Information systems	11,184	12.700	9,800	
CIESIN	5.000	6,000	6.000	
Ocean color data purchase	3,200	1,100	400	
To	317 140	344,300	308,400	

PROGRAM GOALS

The goal of applied research and data analysis is to advance our understanding of the global climate environment, the vulnerability of the environment to both human and natural forces of change, and the provision of numerical models and other tools necessary for understanding global climate change.

STRATEGY FOR ACHIEVING GOALS

The applied research and data analysis program is divided into two major components: Mission to Planet Earth Science (MTPE Science) and Operations, Data Retrieval and Storage. The activities that support MTPE science include research and analysis, EOS science. and airborne science and applications. Operations, data retrieval and storage consist of several independent activities responsible for the operation of currently functioning spacecraft, the purchase and management of scientific data, and the provision of computing infrastructure. Each of the major components of applied research and data analysis has its own set of goals, strategies for achieving the goals, performance measures, and accomplishments and plans. These will be discussed below.

The funding to support the activities of the EOS instrument investigators and interdisciplinary science investigators has been moved to research and analysis in applied research and data analysis. The science algorithm development and maintenance remains in the EOS budget.

BASIS OF FY 1996 FUNDING REQUIREMENT

MTPE SCIENCE

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Research and Analysis	174.912	201.800	185.900
Interdisciplinary	5,000	42,000	62.000
Process studies	125,567	118.300	91.700
Modeling and data	44,345	41.500	32,200
(EOS Science included in interdisciplinary)	(--)	(37,300)	(58,400)
Airborne Science and Applications	25.200	26.000	24.000
To	200.112	227.800	209.900

PROGRAM GOALS

The goal for the MTPE science program is to contribute unique interdisciplinary scientific understanding of the total Earth system and the effects of humankind on the global environment. Major emphasis is placed on providing early warning and fast response to global environmental changes which pose risks to society. The science program also provides the analysis and integration of critical data and models needed for national and international assessments. MTPE Earth system science activities are essential to the design of future operational observing systems and global sustainable development strategies.

STRATEGY FOR ACHIEVING GOALS

RESEARCH AND ANALYSIS

The research and analysis science program is a highly coordinated. collaborative effort. The primary mode of coordination occurs through the U.S. Global Change Research Program, the Committee on the Environment and Natural Resources (CENR) Subcommittee on Global Change Research, and the various boards and committees at the National Academy of Sciences. These coordinating efforts require major investments of time by scientists supported by universities and other federal agencies. The specific task of conducting global Earth system modeling inter-comparisons is supported by the International Geosphere Biosphere Program (IGBP), Global Analysis, Interpretation, and Modeling Project (GAIM).

The strategy of Interdisciplinary Research is to increase scientific understanding of the global environment and its vulnerability to both human and natural forces of change (e.g., pollution. climate variability, deforestation). Interdisciplinary research also

includes the science component of EOS. which consists of both focused research centered around a specific Earth science data set and interdisciplinary research geared toward a broader probe into Earth science systemic functions. The quality of the data utilized is monitored by the scientists at Interdisciplinary Instrument Computing Facilities (IICF) and the research is supplemented by graduate student participation in the EOS science fellowship program. The modeling and data analysis program will synthesize existing environmental data, build component models, and conduct tests and evaluations of model progress. This will provide well documented and tested disciplinary models and data sets to the interdisciplinary science program where integration into global biogeochemical and Earth system models occurs. The process studies program will help Earth scientists understand and predicf global change through planning and support of laboratory and field studies, advanced instrument development, satellite and *in situ* data analysis. and the development of process-scale models and numerical tools to aid in diagnosing and predicting natural and man-induced global environmental change.

There are currently over 1.700 scientific activities being funded under the Research and Analysis Program. Approximately 900 are carried out by universities, 100 by national research laboratories. and 700 by the federal government. The distribution of the activities encompasses forty-five of the fifty U.S. states.

AIRBORNE

The airborne science and applications program funds the operations of three ER-2's, one C-130, and one DC-8 aircraft to support Earth remote-sensing and atmospheric research. They may serve as test beds for newly-developed instrumentation and allow demonstration of new sensor techniques before their flight on satellites or on Shuttle/Spacelab missions. Data obtained from these aircraft are used to refine analytical algorithms, and to develop ground data handling techniques. For example, the ER-2 acquires stratospheric air samples and conducts in-situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in gaining an understanding of stratospheric transport mechanisms.

MEASURES OF PERFORMANCE

Complete a three-year research initiative on the impact of aerosols on atmospheric chemistry and climate September 1996.	A summary assessment of this research program will be distributed to relevant members of the environmental science and policy community. This is important because in contrast to greenhouse gases, sulfate aerosols in the atmosphere can lower surface temperatures of the Earth.
Release results of an international inter-comparison of global vegetation models September 1996	Provide insights and predictions of the response of the land surface to natural and human influences, and to compare obsenred and predicted Earth system behavior.

Participate and support international assessments on-going	Evaluation of impacts of global climate changes for establishing national and international environmental policy decisions (e.g., IPCC and WMO/UNEP ozone assessment).
Biennial peer review on-going	Critique of existing tasks to evaluate their accomplishments/performances.
Complete and release to the public a comprehensive synthesis of the impacts of deforestation in the Brazilian Amazon on global carbon dioxide September 1996	To better understand the importance of the contribution of the deforestation of the Brazilian and Argentinean rain forests to the balance of CO_2 in the atmosphere and, therefore, to the global greenhouse effect.
Assess regional modeling of the impacts of East Asian emissions on ozone pollution in the lower atmosphere downwind emission sources September 1996	To assess and predict the magnitude of air quality impacts from rapid industrialization in Asia and in the remote areas of the Pacific Ocean.
Final scientific results from the Global Tropospheric Experiment (GTE) Pacific Exploratory Mission-West (PEM-WEST) field campaign September 1996	Available for assessment of the impact of the Asian air mass on the oxidizing capacity (cleaning ability) of the atmosphere over the critical clean air portion of the Northern Pacific Basin.
The PEM-Central field campaign September 1996	This airborne science expedition will document the magnitude of air quality impacts from rapid industrialization in Asia on remote regions of the Pacific Ocean. The PEM-CENTRAL is an especially complex campaign. The data from this campaign will determine whether "baseline" (e.g., unpolluted) air exists anywhere on planet Earth. The outcome will elucidate the role of subsonic aircraft in the ozone budget of the lower atmosphere (troposphere).
Assess the impact of biomass burning in South America and Africa on clean air regions of the tropical and subtropical Atlantic ocean basin September 1996	Biomass burning is a major source of tropospheric aerosols, which can change the transmission of the atmosphere, produce pollutants. add green house gases to the atmosphere, and alter the chemistry of the biosphere.

Improve understanding of the carbon dynamics of the boreal forest September 1996	There is presently a large uncertainty in our knowledge of the carbon cycle. This must be resolved to assess whether greenhouse warming will occur and why.
Global Change Fellowship Program annual	The Global Change Fellowship program will help to graduate approximately 30 students each fiscal year, with Ph.D. degrees from interdisciplinary Earth science programs at U.S. universities.
The STRAT and TOTE/VOTE field campaign September 1997	Elements of two major airborne field campaigns will be conducted by the Upper Atmosphere Research Program (UARP) during FY 1995-97: Three deployments of the ER-2. augmented by measurements at high-altitudes using balloons or possibly other available high-altitude platforms will constitute a component of the three-year Stratospheric Tracers of Atmospheric Transport (STRAT) program. Three field campaigns are to be conducted by July 1996. DC-8 campaigns to study Tropical and Vortex Ozone Transport (TOTE/VOTE) will also be conducted in January and February 1996.
The Subsonic Assessment (SASS) field campaign April 1996	To elucidate the role of subsonic aircraft in the ozone budget of the lower atmosphere (troposphere). The first field campaign for this experiment will be completed by January 1996, with an additional campaign occurring in March and April 1996.

ACCOMPLISHMENTS AND PLANS

A major accomplishment of the Research and Analysis Program has been the completion of an extensive field program to assess the effects of aircraft trace gas emissions on stratospheric ozone. The airborne in situ measurements of trace gases utilized the most comprehensive suite of sensors ever deployed. Analysis of the data combined with model calculations will improve understanding of the relevance of heterogeneous processes and stratospheric dynamics in assessing the impact of aircraft operations on the upper atmosphere. In related research, significant advances were made in understanding the degradation pathways of CFC replacement compounds, in order to assess their impact on ozone depletion and global warming, and their toxicity. Almost 300 scientists from 36 countries participated in the "Assessment of Ozone Depletion: 1994" to provide the scientific basis for policy decisions made by parties to the Montreal Protocol and its amendments.

Five Boreal Ecosystem-Atmosphere Study (BOREAS) field campaigns, spanning the seasonal cycle, were conducted this year. More than 250 scientists. 12 aircraft from the U.S. and Canada, and 9 tall towers to make flux measurements were involved, Preliminary results reveal that:

- evaporation rates are lower than current models predict;
- deciduous vegetation has twice the photosynthesis rate as coniferous vegetation;
- despite abundant moisture at the surface, water stress plays a major role in the boreal biome:
- the amount of carbon dioxide sequestered by mid-latitude forests is affected strongly by inter-annual climate variations, influencing the amount of carbon dioxide that accumulates in the atmosphere each year.

In FY 1994, the Earth system science models developed by the EOS interdisciplinary science investigators continued to assist them in understanding the dynamics of Earth's environment and provided support to the IPCC during their assessment of the uncertainty of global climate change. Peer evaluations of completed algorithms were conducted by instrument science teams to validate their physical, chemical, and biological principles. The algorithms successfully completing peer evaluation were placed on the Internet and evaluated by the Earth science community. This is the first time that algorithms developed for upcoming missions have been made available for the external community to critique and qualify before the flight of a mission.

To meet NASA science objectives in FY 1994. the aircraft participated in 24 separate deployments for a total of 93 weeks; they also provided rapid response to National disaster events (e.g., Hurricanes Andrew and Iniki, Mississippi River floods, Southern California and Oakland fire storms, and Search and Rescue).

The international inter-comparison of global vegetation models will require a workshop in Summer 1995. The summary report of results of the assessment will be delivered in December 1995. Data from the Boreal Ecosystem-Atmosphere Study (BOREAS) will be analyzed and assessed to improve climate and weather models, to determine whether the study region is a net source or sink of carbon and methane, and to improve ecological models of the boreal forest biome. The EOS science program will continue to support the activities of the EOS instrument investigators and interdisciplinary science investigators. The investigators will utilize the data gathered by EOSDIS to perform integrated interdisciplinary studies of the Earth to enhance the capability to predict global climate change. In addition, the MTPE interdisciplinary science education strategy focuses on sponsoring global change fellowships for highly qualified graduate students at U.S. universities. In FY 1995. approximately 160 graduate students will be funded under the EOS Science Fellowship Program. Beginning in FY 1995, the activities associated with the interdisciplinary investigation computation facilities have been transferred from EOSDIS to EOS Science. The Airborne Visible Infrared Imaging Spectrometer (AVIRIS) will be used and preliminary work undertaken in preparation for the Small Spacecraft Technology Initiative's Lewis mission; data collected by the Lewis spacecraft will be used to classify surface land cover and vegetation types. In FY 1995, we will complete the of Multi-center Airborne Coherent Atmospheric Wind Sensor (MACAWS) development and science demonstration flights. Light Direction and Ranging (LIDAR), the In-Space Technology Experiment (LITE). data will be delivered to the Langley Research Center Distributed Active Archive Center for access by the scientific community, a science data workshop will be held, with scientific results to be published in the open scientific literature by FY 1996. Beginning in FY 1995, the interdisciplinary science program includes scientific research funding to support post-graduate fellowships and interdisciplinary science investigator grants, as well as some instrument investigators, previously budgeted as part of EOS. The investigators will use the data gathered by EOSDIS to perform integrated, interdisciplinary studies of the Earth to enhance the capability to predict

global climate change. The Subsonic Assessment (SASS) field campaign is currently in the preliminary stages of design. It is anticipated that the field measurements will be conducted in the central U.S. during October-November 1995. The first delivery of scientific results would occur in May 1996.

A workshop involving the participating investigators in the interdisciplinary aerosol research program will be convened in the Fall of 1995. A summary assessment of the impact of aerosols on atmosphere chemistry and climate will be completed and released to the public by August 1996. Surface Radiation Budget (SRB) data will be provided to the to International Satellite Land Surface Climatology Project (ISLSCP), Pathfinder, Global Energy and Water Cycle Experiment (GEWEX), and scientific community in FY 1996. The global short-wave and long-wave SRB data sets (covering the period 1992 to 1995) will be extended to 1996. Validations of the satellite-based algorithms using reliable ground truth data, including the global Baseline Surface Radiation Network (BSRN) and Global Energy Budget Archive (GEBA) data sets, will be completed in FY 1996 and results will be published in the open literature. The current International Satellite Cloud Climatology Project (ISCCP) will be extended from the current 1983-1992 interval to the year 2000. The interval 1982-1995 will be completed by FY 1996. The entire ISCCP climatology will be recalculated in FY 1996 using the improved version *2.0* algorithm. A World Climate Research Program (WCRP) bi-annual ISCCP review workshop will be conducted. The results of the Smoke, Clouds, and Radiation (SCAR)-A (Atlantic), SCAR-C (California), SCAR-B (Brazil) campaigns will be presented in a series of science data workshops and science conferences in FY 1995 and FY 1996, and the results will be published in the scientific literature in FY 1996. The ERBE non-scanner and solar irradiance data will be archived and long-term series analyses, other satellite inter-comparisons. and regional climate phenomena will be conducted in FY 1995 and FY 1996. Results will be published in the open literature in FY 1995 and FY 1996. In FY 1996. the EOS Science Program will continue to perform its activities in a manner consistent with what is planned in FY 1995. The Pacific Exploratory Mission central (PEW-Central field campaign requires pre-mission infrastructure development (e.g., aircraft logistics. supporting ground measurements, etc.) will be completed by early summer 1996. The airborne field campaign will be conducted in August and September 1996.

BASIS OF FY 1996 FUNDING REQUIREMENT

OPERATIONS. DATA RETRIEVAL AND STORAGE

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Mission operations and data analysis	97,644	96,700	82,300
(Upper atmosphere research satellite operations and data analysis)	(30,308)	(30,000)	(18,800)
(Ocean topography experiment operations and data analysis)	(31.052)	(31.400)	(21.400)
(Total ozone mapping spectrometer operations and data analysis)	(3,186)	(3,700)	(3,300)
(Ocean color mission data analysis)	(6,700)	(5,600)	(6,000)
(NASA Scatterometer operations and data analysis)	(--)	(--)	(6,200)
(Earth science mission operations and data analysis)	(26,398)	(26,000)	(26,600)
Information systems	11,184	12,700	9,800
Consortium for international earth science information networks	5,000	6,000	6,000
Ocean color data purchase	3,200	1,100	400
To	117,028	116,500	98,500
Launch services (radarsat)	(7,400)	(7,000)	(--)

PROGRAM GOALS

The Operations, Data Retrieval and Storage (ODRS) program provides the data and data products from EOS precursor missions, including the Upper Atmosphere Research Satellite (UARS), the Ocean Topography Experiment (TOPEX), Total Ozone Mapping Spectrometer (TOMS), and future missions such as the NASA Scatterometer and the tropical rainfall measuring mission, required to understand the total Earth system and the effects of humans on the global environment.

STRATEGY FOR ACHIEVING GOALS

The ODRS program supports the observations and data management portion of the activities including process research, integrated modeling and prediction, and assessments that together produce a predictive understanding of the Earth system. The ODRS program will achieve its goals through the following: Mission Operations and Data Analysis (MO&DA); information systems:

Consortium for International Earth Science Information Networks (CIESIN):and ocean color data purchase. The data and data products from the ODRS program will migrate to the EOSDIS.

Mission Operations and Data Analysis

The objectives of the MO&DA program *are* to acquire, process, and archive long-term data sets and validated data products. These data sets support global change research in atmospheric ozone and trace chemical species. the Earth's radiation budget, aerosols. sea ice. land surface properties, and ocean circulation and biology. Funding provides for operating spacecraft such as UARS, TOPEX and ERBS, processing of acquired data, validating the resulting data products by science teams, and developing new processing software and related data products by these science teams as they apply new understanding to improve the data products.

Investigators, international contributors, and other agencies supporting MO&DA missions include diverse governmental, industry, and university users involved in the research and operational use of data for monitoring the Earth's atmosphere (Upper Atmosphere Research Satellite (UARS). TOMS, SBUV/2, Earth Radiation Budget Satellite's (ERBS)).oceans (Ocean Topography Experiment (TOPEX), SeaStar, NSCAT. European Space Agency's Earth Remote Sensing Satellite-1/2 (ERS-1/2), Japanese Earth Remote Sensing Satellite-1 (JERS-1), RadarSat) and land masses (SIR-C). Key users of UARS data include NOM the Naval Research Laboratory, GSFC, JPL, Canada, the United Kingdom, and a number of universities including the University of Michigan, the Georgia Institute of Technology, the University of Washington, the State University of New York, and the University of Colorado. Key TOMS and SBUV/2 proponents include NOM Russia (manifested a TOMS on their Meteor 3 satellite launched in 1991), Japan (hasmanifested a TOMS on their ADEOS satellite scheduled for launch in 1996)and Europe. Key ERBS users include a diverse set of institutions including NOAA (manifested ERB sensors on NOAA-9 and -10 launched in the 1980's), GSFC, LaRC, the State University of New York, Oregon State University, and the Scripps Institution of Oceanography.

The TOPEX users include France (shared in development of the mission), Japan, Australia, Great Britain, the Netherlands, Germany, Norway, and South Africa as well as JPL. GSFC, Columbia University, the University of Hawaii. University of Texas, University of Colorado, Oregon State University, Ohio State University, and Massachusetts Institute of Technology. SeaStar principal beneficiaries include the Orbital Sciences Corporation, GSFC. the European community, Japan, Canada, and Australia and a diverse group of universities in Florida, Washington, California, Texas, Maryland, and Rhode Island. The NSCAT participants include JPL, NOM and Japan (which has manifested the NSCAT for flight on their ADEOS spacecraft scheduled for launch in 1996), and universities in New York, Washington, Oregon. and Florida. Key participants involved in the Alaska *SAR* Facility (ASF) include the European Space Agency (ERS-1 and -2), Japan (JERS-1 and ADEOS). Canada (RadarSat), GSFC, JPL, and the University of Alaska which hosts the ASF. Participants in the analysis of SIR-C/X-SAR data in addition to JPL, represent nations in almost every continent including Italy, Saudi Arabia, China, Australia, France. Canada, Brazil, the United Kingdom, and Germany.

Information Systems

The MTPE information system program has been structured to provide a balanced system of high performance computers, mass storage systems, workstations and appropriate network connectivity between researchers and components of the system. A major portion of the program funding supports operations of a supercomputing center (the NASA Center for Computational Sciences) at GSFC. A full range of computational services are provided to a community of approximately 1400 users representing all disciplines of Earth and space sciences. Offsite NASA-sponsored users comprise some 25% of the total. The program has also been structured to take advantage of new technology as it reaches production maturity. The program monitors and participates in advanced technology programs. such as the High Performance Computing and Communications (HPCC) program and National Science Foundation's Gigabit Testbed programs. Program elements at GSFC and the JPL are focused on providing early access to emerging technologies for the Earth and space science communities.

Users of the supercomputer complex select representatives to an advisory committee who are integrally involved in strategic planning for the evolution of the complex. They provide feedback on user satisfaction with services provided and help establish priorities for service and capacity upgrades. The early access to new technology provides the program with the opportunity to influence vendors and system developers on issues unique to the Earth and space science researchers such as data intensive computation and algorithm development. Early access also prepares a subset of the research community to make needed changes in research methodology to exploit the new technologies and to champion promising technologies to their colleagues and peers. Ten percent of the program's funding is used to assure the continuing participation of the science community in this important collaborative partnership between technologists and researchers.

Consortium for International Earth Science Information Networks

CIESIN's objective is to increase understanding of the human dimensions of global change by developing and operating the Socio Economic Data Application Center (SEDAC) in Saginaw. MI. The strategy is to focus specifically on development of SEDAC and its integration into NASA's Earth Observing System Data Infomation System (EOSDIS). SEDAC serves as a Distributed Active Archive Center (DAAC). SEDAC provides access to social and economic data for integration with EOSDIS Earth science data to allow interdisciplinary global change research as well as to facilitate use of Mission to Planet Earth data for public policy making. SEDAC has been incorporated into all activities associated with the management of the DAAC's.

Ocean Color Data Purchase

The scientific objectives of the Ocean Color Mission are to determine the mean and variable bio-optical reflectance characteristics of the upper ocean and to understand the processes responsible for observed variations. NASA is purchasing ocean color data sets for research use from Orbital Sciences Corporation on a fixed-price contract. Payments are phased before and after launch. The data will be acquired by the Sea-Viewing Wide Field Sensor (SeaWiFS) instrument. now expected to be launched on the SeaStar spacecraft in 1995. Orbital Sciences is responsible for SeaStar/SeaWifs development, Pegasus launch, and operations. Orbital Sciences will share the cost with NASA by retaining the right to market the data to the operational and commercial communities as well as those research users who wish to purchase data directly from them. International governmental and non-governmental

bodies have been, and continue to be, active in the development of the U.S. ocean color program. Principal proponents include the European Community, Japan, Canada, and Australia. At present, the largest demand for ocean color data arises from the Joint Global Ocean Flux Study (JGOFS), an international program under the auspices of the Scientific Committee for Oceanographic Research (SCOR), which is a core program of the International Geosphere-Biosphere Program (IGBP).

MEASURES OF PERFORMANCE

OPERATIONAL SPACECRAFT/INSTRUMENTS

Common: Archive 95% of planned data acquisition	The primary criteria for success of an operational spacecraft is to obtain 95% of the planned data acquisition.

MISSION SPECIFIC:

UARS launched September 1991	The success of UARS operations is judged on providing data to support improvement in monitoring the processes that control upper atmospheric structure and variability, the response of the upper atmosphere to natural and human-induced changes, and the role of the upper atmosphere in climate variability.
TOPEX/Poseidon launched August 1992	10-cm surface height is required of the spacecraft's radar altimetry instruments in determinations of speed and direction of surface currents, oceanic heat transport. and ocean topography in support of climate change monitoring.
TOMS-Meteor 3 launched August 1991	Data from TOMS are required to be of sufficient accuracy to detect total ozone trends and verify chemical models of the stratosphere used to predict future trends.
ERBS/ERBE (launched Oct. 1984, Dec. 1984 and Sept. 1986)	Data from the ERBS must continue to be of sufficient accuracy to illuminate the temporal and spatial variations in the Earth's radiation budget which drive the Earth's climate.

SBUV/2-SSBUV (launched Dec. 1984 and Sept. 1988)	Data from the Solar Backscatter Ultraviolet/2 (SBUV/2) instruments provide column abundances and vertical profiles of atmospheric ozone beneath the orbital tracks of these satellites. A carefully calibrated version of the same instrument, called Shuttle SBW (SSBUV) provides correlative measurements so that the TOMS and SBW instruments flying on other spacecraft can be more accurately calibrated, and provides information on the diurnal variability of stratospheric ozone in low latitudes.
Alaska SAR Facility Missions: ERS-1 (launched 1991) JERS-1 (launched 1992) ERS-2 (to be launched 2nd quarter 1995) RadarSat (to be launched 4th quarter 1995) ADEOS (to be launched 2nd quarter 1996)	Data received at the ASF must support determination of the properties and dynamics of sea ice and other land and sea processes in the polar regions. Data from SIR-C are required to identify the optimum wavelengths, polarization. and illumination geometries for determination of surface parameters to include roughness, soil moisture, and variability in geological formations.
SPACECRAFT TO BE LAUNCHED:	
OTD 1995	The Optical Transient Detector (OTD) will provide early acquisition of science data to support research in determining global distribution of lightning and its effects on climate change. It will allow for an early engineering flight of the Earth Observing System Lightning Imaging Sensor (LIS) instrument and concept validation, including the high speed solid-state camera system and real-time event processor, and will be a pathfinder for commercial remote sensing applications of lightning data.
Seastar/Ocean Color 1995	Measurements will be made of up-welling radiance at eight spectral bands in the visible and near infrared portions of the spectrum at a spatial resolution of 1 kilometer. The entire cloud-free globe will be imaged once per day. Data products will include daily global maps of oceanic pigment concentration; optical attenuation length scales ;and visible, water-leaving radiance. The data delivered to NASA shall meet radiometric performance specifications set forth in the contract with Orbital Sciences. These include specifications for the instrument data bands, signal-to-noise ratio, and radiance levels. The data streams will also contain all necessary information required for processing the radiance data, including predicted ephemerides and calibrations, spacecraft attitude, time, tilt. gain, and other necessary spacecraft and sensor information.

CIESIN Critical design review February 1995	The CDR is the final review of the system design before implementation. It is essential that NASA review the SEDAC system design to ensure interoperability with EOSDIS.
CIESIN System operating capability testing August 1995.	This test of system capability must be conducted so that NASA is assured that the system meets its operating requirements.
CIESIN System operational services begin September 1995	SEDAC services must be ready to ensure overall EOSDIS services are available.
CIESIN "Lessons learned design review November 1995	After several months of operation, a review will be performed to optimize system performance and ensure that SEDAC is operating efficiently.

ACCOMPLISHMENTS AND PLANS

Data has been acquired, processed, disseminated. and archived to meet mission requirements for user availability of timely and accurate data products for global and/or regional monitoring purposes from all operational spacecraft and instruments. The current emphasis on global modeling in support of policy decision on such matters as the impact of deforestation, ozone depletion, and environmental quality worldwide has led to the acquisition and manipulation of unprecedented amounts of environmental data. The accompanying computational demands has led to a doubling of production computing capacity and quadrupling of mass storage capacity in the last two fiscal years. The funding vehicle for CIESIN was changed from a grant to a specific SEDAC contract on June 28, 1994, to establish compatibility of SEDAC with the overall EOSDIS. SEDAC development milestones are now linked to those of EOSDIS. SEDAC completed the program management review in August 1994.

In the MO&DA program. responsibility for assigned missions is assumed 30 days after launch. Data are acquired, processed, disseminated, and archived to meet mission requirements for user availability of timely and accurate data products. Missions supported will be those scheduled for launch in 1995 (TOMS and SeaStar) , as well as the inauguration of data receipt for ERS-2 and RadarSat at the ASF. The MTPE information systems program will continue to provide a balanced computational environment for NASA science researchers primarily through facilities housed at GSFC and the JPL. It will continue to make cost-effective, user requested enhancements to these facilities and will continue to leverage technology programs such as the High-Performance Computing and Communications (HPCC). Projected demands have led to the establishment of new partnerships with other agencies (i.e. National Security Agency, National Science Foundation, and Department of Energy) and vendors (i.e., International Business Machines, Cray Research, and Convex) to seek solutions to production related problems in emerging computational environments. CIESIN will conduct a requirements review in October 1994 and a preliminary design review in November 1994. SEDAC is now on-line with Internet access and providing limited data products to the research community and the public.

User requirements will be met in 1996 by continuing operations of in-orbit spacecraft and instruments including the UARS, TOPEX, and ERBS missions: continuing processing and analysis of data from the SRL mission, continuing support of the SBUV/2 sensor and processing of data from the SSBUV. and continuing receipt of ERS-1 and JERS-1 data at the Alaska SAR Facility.

Missions to be supported that are scheduled for launch in 1996 include the NSCAT and TOMS on ADEOS. The MTPE information systems program will continue to provide a balanced computational environment for NASA science researchers primarily through facilities housed at GSFC and the JPL. Partnerships with industry and other federal agencies will be used to assure the presence of the program's requirements in the strategic planning of new computational technologies. Funding to CIESIN will provide personnel and equipment for the development of the system necessary to acquire socio-economic data, maintain that data in an archive, and provide the necessary access and data distribution to carry out global change research.

BASIS OF FY 1996 FUNDING REQUIREMENT

GLOBAL OBSERVATIONS TO BENEFIT THE ENVIRONMENT

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996
Global observations to benefit the environment.....	[300]	5.000	5.000

PROGRAM GOALS

The goal of the Global Observations to Benefit the Environment (GLOBE) Initiative is to link scientific discovery with the education process in the study of the Earth as an integrated system. The objective is to bring school children, teachers, and scientists together to: (1) enhance environmental awareness of individuals throughout the world: (2) contribute to scientific understanding of the Earth: and (3) help all students reach higher standards in science and mathematics.

STRATEGY FOR ACHIEVING GOALS

The GLOBE Initiative involves students (K-12 or equivalent) in schools throughout the world. their teachers and the environmental science research community. Each school (representing K-12) will make a set of GLOBE measurements using GLOBE instruments and procedures under the guidance of GLOBE-trained teachers. These results from all over the world will be transmitted to a central data processing facility. The students will then receive global images as feedback and will use GLOBE educational materials to understand the compiled results and to do their own analyses of the data.

In order to meet the first objective of increasing international environmental awareness, the program has been designed to be international in scope. involving students, educators and researchers from all over the world. By using the Internet to link the schools together. a sharing of discoveries and analysis is encouraged that should result in awareness beyond just the local community.

The second objective of contributing to the scientific understanding of the Earth is achievable due to the expansive data set that will result from long term, repeated measurements made around the globe with special value in areas where data have not been available in the past. To ensure the greatest possible accuracy of the data, international environmental scientists have been involved from the beginning of the program to select a set of significant scientific measurements that can be made by students and to define the experimental procedures and data reporting protocols for each.

GLOBE's intent is to provide hands-on, interactive learning experiences for students in order to meet the final objective. Based on the proven assumption that people learn by doing, GLOBE provides a mechanism for students to become active scientists and know that their research will be used by the professional scientific community. The GLOBE educational materials will provide the

tools for the trained teachers to give proper context to each measurement and to suggest follow-on activities that directly support science and mathematics standards.

MEASURES OF PERFORMANCE

Achieve participation of at least 200 schools April 1995	By the 25th Earth Day, the start-up program will be well under way with at least 200 schools actively participating and making measurements. About half of the 200 schools are to be located outside of the United States to ensure the global nature of the program. Start-up principal investigators will have specified the measurements and worked with educators to develop adequate materials for teacher training and curriculum support. The data systems component will also be operational.

ACCOMPLISHMENTS AND PLANS

NASA's contribution to GLOBE includes participation in the identification of the start-up measurements, participation in the review of the proposals by scientists and educators to carry out the long term scientific and educational aspects of the program, developing the data visualization and leading the Internet effort. NASA, as a participating agency, also serves in an oversight capacity through a management steering committee and leadership council.

A science workshop was held in September 1994, to solicit input from international environmental scientists in order to identify a list of start-up measurements that are scientifically significant and reasonable for students to make with small error margins.

GLOBE has already achieved many of its significant milestones during FY 1995. In December 1994. an education workshop was held to review existing environmental education materials with a panel of experts to determine the age-appropriate "kit" that will be provided to each teacher who undergoes the training program planned to be under way in late February 1995. In parallel, GLOBE released a competitive announcement of opportunity to solicit proposals from scientists and educators that will implement the long-term program. Awards are expected to be made in March 1995. The school selection process is under way with an application form provided to every school district in the United States. Any school meeting the minimum set of requirements will be accepted as a GLOBE school and others that require federal assistance will be chosen based on a prioritized set of criteria.

By FY 1996, the GLOBE development process will be complete. Evaluation of the start-up activity is essential to ensure that the long-term program will be successful. Growth is anticipated as schools are continually accepted into the program. The long-term science and education teams will evaluate the start-up measurements and make modifications to procedures, materials and the training program as necessary. The start-up phase will provide an estimate for the systems support required to maintain the Internet and data base. Therefore, FY 1996 is expected to be a time of examination, adjustment and final implementation.

BASIS OF FY 1996 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996
Advanced communications technology satellite	3.000	2.300	---
Upper stage	(2,000)	(--)	(--I

PROGRAM GOALS

The Advanced Communications Technology Satellite (ACTS) program maintains U.S. leadership in the communications satellite market through the development and flight verification of advanced technologies that enhance the capability of communications satellites. The main industrial ACTS development contractors were Martin Marietta Astro Space, with design support from TRW and Motorola.

The U.S. user community, representing some 85 private sector organizations, universities and other government agencies, is conducting experiments to test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high gain power, fast-hopping multiple beam antenna: on-board intermediate frequency and baseband switching; wide bandwidth (1 GBPS) transponders, Ka-band components: and dynamic rain fade compensation techniques.

The transfer of the ACTS technology to the industry is proceeding. Commercial systems which are being built using ACTS technology are a global mobile communications system called Iridium by Motorola (the developer of the ACTS on-board switching). the video phone system by Hughes, the global fixed service system by Calling Communications and the home video system by Norris Communications.

The ACTS satellite was successfully deployed by the shuttle on September 12, 1993, and arrived on station in geostationary orbit approximately two weeks later. The satellite, the master control station and multiple Earth stations were successfully checked out. In January 1994, the experiment period began during which 78 experiments are scheduled to utilize ACTS technologies.

The FY 1995 budget provided the final increment of funding in this budget line required for mission operations at the Lewis Research Center. Beginning in FY 1996, funding responsibility for ACTS mission operations and experiments is transferred to the Office of Space Access and Technology.

BASIS OF FY 1996 FUNDING REQUIREMENT

LAUNCH SERVICES

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
EOS launch services	16,200	41,700	88,000
Radarsat launch services	7,400	7,000	--
ACTS upper stage	2,000	--	--
TOMS earth probe launch services	900	--	--
Launch services	26,500	48,700	88,000

PROGRAM GOALS

The goal of the launch services within the Mission to Planet Earth program is to provide the flight programs with successful, cost-effective, and on-time expendable launch vehicle (ELV) launch services.

STRATEGY FOR ACHIEVING GOALS

Funding for mission unique launch services is included under the budget for the benefiting program. While funding for the ELVs is found within the MTPE budget, program management for the ELVs rests with the Launch Vehicles Office (LVO) within NASA. The LVO aggregates NASA, NOAA, and international cooperative ELV mission requirements, establishes appropriate acquisition strategies for purchasing firm, fixed priced launch services from the U.S. industry, and imposes the scope and level of technical oversight of the commercial ELV operators' delivery of service that reflects the criticality of the mission and the level of government resources at risk. The objective is to provide affordable, 100 percent successful delivery to space.

Since 1987, the LVO has been employing a national mixed fleet strategy, with 100 percent successful launch services. The administration, procurement, and technical oversight of launch service delivery in the small and medium performance classes is managed by the Goddard Space Flight Center (Atlas-E, Titan II, Pegasus XL, and Delta II, Ultra-Lite and Med-Lite.) The intermediate and large performance classes launch services (Atlas I/IIAS and Titan IV/Centaur) are managed by the Lewis Research Center. The Kennedy Space Center is delegated responsibility for technical oversight of vehicle assembly and testing at the launch site by GSFC and LeRC and is responsible for launch site the spacecraft processing. The current corporate participants include Martin Marietta for AM-1, McDonnell Douglas for Landsat-7 and RADARSAT, and Orbital Sciences Corporation for TOMS.

MEASURES OF PERFORMANCE

Launch of TOMS Earth probe, July 1995	Launch as planned aboard the Pegasus XL/L1011 launch vehicle. Exact date of this launch is dependent upon the successful return to flight of the Pegasus XL/L1011.
Launch of RADARSAT September 1995	Launch as planned aboard a Delta 11. This mission is an international cooperative ELV mission with Canada in which NASA provides the launch services and Canada provides the spacecraft.

ACCOMPLISHMENTS AND PLANS

Over the last year, the launch services program has worked to minimize the consequences to NASA of the Pegasus XL/L1011 failure. and to facilitate and monitor plans for the launch vehicle's successful return to flight. -The Intermediate ELV (IELV) launch services contractor was selected

The key goal is to provide launch of the TOMS and RadarSat and maintain the EOS AM-1 and Landsat-7 launch services programs.

Award the med-lite contracts for the EOS Altimetry missions and continue funding in support of the EOS AM-1 and Landsat-7 launches in 1998

BASIS OF FY 1996 FUNDING REQUIREMENT

CONSTRUC OF I

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996
Earth systems science building	12,000	17,000	17,000
Langley Research Center distributed active archive center	6.000	--	--
Construction of facilities	18,000	17.000	17,000

PROGRAM GOALS

The goal of the Earth systems science building project is to construct facilities which will house civil service, contractor, and visiting scientists conducting global change and Earth science research using the Earth Observation System (EOS). The FY 1994 funding for the Langley Research Center distributed active archive center completed funding for the EOSDIS facility at the Langley Research Center.

STRATEGY FOR ACHIEVING GOALS

Facility design and initial construction began in FY 1994 for the Earth systems science building (ESSB) at the Goddard Space Flight Center. A second increment of funding was provided in FY 1995 for continuation of construction with completion funded by the FY 1996 Construction of Facilities request.

The complete description of the ESSB construction is in the Mission Support section of the FY 1996 budget justification.

Aeronautical
Research and
Technology

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS **AERONAUTICAL RESEARCH AND TECHNOLOGY**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	Page Number
Aeronautical research and technology	844,200	860.000	911,900	SAT 4-3
Transatmospheric research and technology	20,000	--	--	SAT 4-44
Construction of facilities	203.000	22.000	5.400	SAT 4-46
To	1.067.200	882.000	917.300	
National aeronautical facilities.		400.000		
Distribution of Program Amount Bv Installation				
Johnson Space Center	600	400	100	
Marshall Space Flight Center	800	700	200	
Stennis Space Center	500	200	--	
Ames Research Center - SAT..	211,700	212,800	241,500	
Ames Research Center - CoF	51,000	22,000	5,400	
Dryden Flight Research Center	51,700	48.900	45,800	
Langley Research Center - SAT	312,100	305.500	331,700	
Langley Research Center - CoF	51,000	--	--	
Lewis Research Center - SAT	231,300	243,700	247,300	
Lewis Research Center - CoF	27,000	--	--	
Goddard Space Flight Center	18,500	25,300	21.300	
Jet Propulsion Laboratory	9,400	5.600	5,600	
Headquarte	27,600	16.900	18,400	
Various locations - construction of facilities	74,000	--	--	
To	1.067.200	882.000	917.300	

OFFICE OF AERONAUTICS

AERONAUTICAL RESEARCH AND TECHNOLOGY

PROGRAM GOALS

The goal of the Aeronautics Research and Technology program is to provide the Nation with leadership in high-payoff, critical technologies, and to assure the effective transfer of research and technology products to industry, the Department of Defense (DoD), and the Federal Aviation Administration (FAA) for application to safe, economically superior. and environmentally responsible U.S. civil and military aircraft, and for a safe and efficient national airspace system.

! 'E FOR CHIEVING GOALS

NASA carries out its aeronautics mission in close partnership with the DoD, FAA, U.S. industry, and academia. The program reflects the continued need to address critical technology and performance barriers and to strengthen technology development in selected high-payoff areas vital to our long-term leadership in aviation. NASA's Aeronautics program is focused around six strategic goals:

(1) develop high-payoff technologies for a new generation of environmentally compatible. economically superior U.S. subsonic aircraft and a safe, highly productive global air transportation system:
(2) ready the technology base for an economtcally viable and environmentally friendly high-speed civil transport:
(3) ready the technology options for new capabilities in high-performance aircraft;
(4) develop and demonstrate technologies for hypersonic airbreathing flight:
(5) develop advanced concepts, physical understanding, and theoretical, experimental, and computational tools to enable advanced aerospace systems: and
(6) develop, maintain, and operate critical national facilities for aeronautical research and for support of industry. FAA. DoD, and other NASA programs.

In accomplishing these goals, an integral part of NASA's strategy is an emphasis on customer involvement in the planning, implementation and technology transfer phases of aeronautics programs. A high priority is placed on the productive and cost-effective provision of products and services, timely transfer of technology to domestic customers, strong university involvement, and the inclusion of minorities and disadvantaged businesses in the conduct of its aeronautics programs. Research implementation is carried out cooperatively among NASA Research Centers, industry and academic researchers in a manner that utilizes the strengths of each partner. The NASA centers also provide critical, unique national facilities to all customers for research and technology development.

BASIS OF FY 1996 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Aerodynamics	139,140	114.800	119,300
Propulsion and power	72,475	75,300	69,400
Materials and structures	49.075	39,600	46.400
Controls. guidance and human factors	65,640	48,800	45.900
Flight systems	60,440	47,200	45,200
Systems analysis	7,530	8,600	8.500
Hypersonics	26,000	32,000	20,000
To	420,300	366 ,300	354,700

PROGRAM GOALS

The Research and Technology (R&T) Base program is an essential element of the Aeronautics program, for it is here that new technologies that lead to superior products *are* conceived. The Base program provides a foundation on which: (1) to develop advanced technology concepts and methodologies for application by industry; (2) to build focused programs to address selected national needs: (3) to respond quickly to critical safety and other issues; (4) to provide facilities and expert consultation for industry during their product development; and (5) to develop and demonstrate enabling technologies for twenty-first-century, airbreathing hypersonic systems.

STRATEGY FOR ACHIEVING GOALS

Working closely with its customers, NASA's R&T Base program has helped the U.S. lead the world in aeronautical breakthroughs and advanced aviation concepts. many of which have been incorporated by industry. Additionally. it provides a foundation to respond to national issues. For example, in the early 1970s. NASA was able to respond to the national fuel crises by rapidly implementing the Aircraft Energy Efficiency program which accelerated the development of technologies resident in the Base. Concepts which can be traced to early research funded in the R&T Base, and were subsequently inserted into commercial products include: (1) Supercritical Wing for the B-757 and B-767 aircraft, (2) winglets for the MD-11 and B-747-400; (3) acoustic nacelles for the MD-11. B-757. B-767, B-747; (4) active turbine cooling for the JT9D engine and the B-747; (5) composite structures and advanced aluminum alloys for the B-757. B-767, B-747. and the MD-11; (6) advance displays for the B-757, B-767, B-747. B-777; (7) digital fly-by-wire for the F-18A, F-16C/D; (8) stall, spin & crash worthiness for general aviation; and (9) wind shear detection for all transports.

The R&T Base program includes these aeronautics disciplines: aerodynamics: propulsion and power: materials and structures: controls, guidance and human factors; and flight systems. The R&T Base also provides the resources required to maintain aeronautics flight research, as well as ground-based experimental and computational facilities. Emphases in systems analysis and multidisciplinary research, the combining of two or more disciplines into a single activity. have been increased because of improvements in aircraft systems that may be obtained with integrated design approaches. Hypersonics tasks, primarily in aeropropulsion and aerothermodynamics. receive special attention since they address the unusually challenging environments for aerospace planes. Each element of the R&T Base program has an added objective of developing multidisciplinary methods that will contribute to industry's goal of reducing design cycle time by 50%. This goal is driven by the need to reduce product costs and capture increased market share. The R&T Base also maintains research on various vehicle classes. A significant portion of research and concept development in the 'Baseprogram is performed through cooperative agreements with the industry and other Government agencies facilitating rapid technology transfer.

Finally, the R&T Base program supports the capability to implement and conduct the research activities described above by providing a facilities infrastructure which supports the R&T Base, focused programs, and industrial development activities. The major aeronautical facilities and services are located at the four aeronautical research centers - Ames Research Center (ARC), Dryden Flight Research Center (DFRC), Langley Research Center (LaRC), and Lewis Research Center (LeRC).

The strategy of the R&T Base program is described below according to the principal aeronautics disciplines. A vision or long range plan has been developed for each discipline as well as a number of objectives (plans) for achieving that vision.

Aerodynamics: Provide a world-class aerodynamic research capability that combines wind tunnels, instrumentation, computational analysis, and flight research to develop technology for the U.S. industry and DoD so they can develop economical, safe, quiet, globally competitive aircraft across the speed range.

Objective (1): Develop and validate practical and reliable aerodynamic design methods and concepts in high-payoff subsonic aircraft technology areas. A number of aerodynamic technologies offer the potential for cost reductions in acquiring and operating aircraft through increased performance and decreased design time. Promising technology areas being addressed are laminar flow, high-lift systems and configuration aerodynamics. The design of these systems remains a technical challenge due 'to limited understanding of complex flow phenomena and difficulty in extrapolating system performance from ground-based results. Tools are being developed and validated which will enable a more complete understanding of complex flow fields about multiple-component wing configurations. Through joint programs with industry, aerodynamics research will develop methodologies enabling integration of these technologies into improved wing designs.

Objective (2): Develop critical aeromechanics technologies that enable well-designed, economically viable rotorcraft, gain greater passenger and community acceptance of a civil rotorcraft, and improve productivity and component life. New technologies are required to increase performance and enhance tactical effectiveness of military rotorcraft, through greater agility and maneuverability. Developing and validating improved rotary aerodynamic analysis and advanced aeromechanics concepts integrated with large-scale wind tunnel testing and flight research will provide U.S. industry with comprehensive methods for

the development of helicopter and high speed rotorcraft. Benefits of such systems include performance improvement, noise reduction. and vibration and loads alleviation.

Objective (3): Pioneer the development of advanced computational and experimental design tools. facilities instrumentation. and flow control concepts to solve aerodynamic problems inhibiting the development of new generations of aircraft. Future significant improvements in vehicle performance. fuel efficiency, safety, and environmental compatibility require the understanding, predicting. and controlling of boundary-layer transition, turbulence, and vortical flows at flight Reynolds numbers. Therefore, an enhanced understanding of viscous flow physics is required. Advanced flow measurement and diagnostics technology and computational fluid dynamics continue development toward understanding while providing data bases for developing and validating the physics models. Ground test facilities and computational methods provide data bases to calibrate and validate advanced models. University research is an integral part that advances aerodynamics while training future scientists and engineers.

Propulsion & Dower: develop and transfer advanced, innovative propulsion & power technologies to the U.S. aeropropulsion industry for future generations of world class. safe. economical, environmentally compatible air-breathing engines and rotorcraft transmissions.

Objective (1): Develop the tools required for the U.S. aeropropulsion industry to design aeronautical gas turbine engine components and rotorcraft transmissions that are highly efficient, operable, and reliable. Efforts in this program focus on improved understanding and predictive capability for critical propulsion components, such as compressors, combustors. turbines and gears, through development and validation of improved analysis tools and fundamental and applied experiments. Turbomachinery efforts concentrate on achieving improved levels of aerodynamic efficiency, improved cooling effectiveness. and enhanced operability for axial and radial type machines. Combustor research develops advanced technologies for gas turbine combustors with reduced Nitrous Oxide (NOx), unburned hydrocarbons, carbon monoxide, and soot emissions. The effects of high pressure, high temperature and varying pattern factors on the operational range, durability, and performance of advanced combustors for small engine applications are being researched. Transmission efforts emphasize reduced gear noise and vibration, improved life and reliability of drive systems, and lightweight design concepts.

Objective (2): Develop and transfer to customers advanced propulsion research instrumentation; advanced integrated flight/propulsion controls, high stability engine controls, fiber optic-based control sensors: dynamic models of advanced propulsion systems: and high temperature electronics technology based on silicon carbide. Propulsion research instrumentation supports a wide variety of experimental efforts that range from fundamental studies to complete engine system tests. These efforts focus on miniature sensors and non-intrusive remote sensing measurement systems. Advanced controls will achieve maximum levels of propulsion system performance and life while maintaining adequate safety margins. A top-down systematic approach for designing near-optimal integrated flight/propulsion control systems, and the development of approaches for enhancing the operating stability of advanced turbine engines is the focus of this research. This research develops advanced passive optical sensors for use in fiber-optic-based control systems where minimum weight, size. and immunity to electromagnetic interference (EMI) are important. The Silicon carbide-based electronics hold promise for high

temperature (up to 500°C) operation. The focus is on materials and device development and integrated electronic sensors for high temperature propulsion applications.

Objective (3): Establish a validated interactive, interdisciplinary "numerical test cell" for propulsion systems and components, and conduct potentially high payoff research on innovative propulsion concepts. This research combines computational and experimental elements to improve the fundamental understanding of flow physics in inlets, nozzles, turbomachinery. and combustors. Advanced models and analysis tools integrated into an engine simulation environment designed to provide multidisciplinary analysis will result. This "numerical test cell" project is designated the Numerical Propulsion System Simulator (NPSS). It will provide faster and less expensive methods for doing both component and system analyses and design. The NPSS will allow numerical simulation to replace many expensive, large-scale system tests.

Materials and structures: conduct research for the development and application of advanced materials and structures technologies to reduce manufacturing cost and structural weight, enhance performance, reduce noise, insure safety, reliability, and durability. and reduce development cycle time for future rotorcraft and aircraft airframe and propulsion systems.

Objective (1): Provide high temperature advanced materials for applications in subsonic propulsion systems by developing a detailed understanding of material chemistry, architecture, processing, fiber/matrix interaction, life prediction and failure mechanisms. Advanced materials could provide up to 36% savings in engine weight, 40% fuel savings, and 10% reductions in direct operating costs. Polymer matrix composite technology research for fan and compressor applications is underway. The approach extends in-house developed resin temperature capability to 600°F (currently at 300°F) while enabling low-cost manufacturing of components for ducts, cases, fairings, fan vanes, and compressor ducts and cases. Technical challenges include: developing matrices with improved thermal oxidative stability and processability, coatings and fiber sizing, processing methods, and life prediction. For compressor applications, the approach includes developing metal matrix/intermetallic matrix composites with integrity to 1800°F (currently unavailable) for potential applications in cases, blades. vanes. and disks. For turbine applications, intermetallic matrix composites are being developed to 2300°F integrity. Monolithic alloys research in nickel-base superalloys and gamma titanium-aluminides are nearer term solutions to compressor needs. Such materials are required for compressor components to 1500°F (currently at 1150°F) to achieve increases in efficiency by increasing pressure ratios from 40/1 (1200°F) to 60/1 (1500°F). Ceramic Matrix Composites are being developed for application to components in the hot temperature section of the turbine. Glass-based ceramics under development have application to 2000°F (currently unavailable) while non-oxide and selected oxide systems are targeted for turbine applications greater than 2500°F (currently unavailable).

Objective (2): Develop advanced analysis tools and innovative technologies required for the reduction of rotorcraft noise. vibration, weight, and manufacturing cost. Design and analysis tools for acoustics, dynamics, vibrations, and aeroelasticity will be advanced for use by the rotorcraft industry. Wind tunnel experiments will include powered scaled models and full scale flight test measurements to understand the complex aeroacoustic phenomena and to provide validation data. Analytical techniques will provide new passive and active control concepts to reduce noise and vibration. and experimental programs will verify the concepts. The program provides for design, build, and test of advanced structural concepts that use composite materials for lower weight with increased stiffness. Hardware development and flight testing is pursued with close coordination

between NASA fixed wing and rotorcraft programs and Army research programs, as well as industry partnerships and cost sharing programs.

Objective (3): Develop structures and materials technologies for increasing efficiency and reducing the cost of the next generation aircraft. Include advanced composite and metallic materials within primary aircraft structure and introduce high temperature materials into engine structure. To increase the competitiveness of the next generation of aircraft, advanced materials will be available for primary airframe and engine structures. Research to develop technologies that reduce design cycle time and manufacturing costs, and ensure that structures are more durable and damage tolerant is the focus of this program. The program develops advanced composite and metallic materials and associated processing and fabrication technologies. The program develops computational models and thermal analysis methods for integrated, optimal airframe design. Research provides models for predicting the failure of structures, and full-scale components will be tested for verification. Structural models include developed mechanics models that describe the deformation, strength, and life of advanced materials. To ensure aircraft safety, this program develops advanced methods to predict and control aeroelastic and structural dynamic responses.

Controls, Guidance & Human Factors: develop the controls, guidance and human factors technological foundation to enable U.S. leadership in providing significant improvements in mission operations of aircraft and to enable new mission capabilities.

Objective (1): Apply and validate enabling technologies in the areas of guidance, controls, human factors, information systems, and aviation sensors to provide improvements in the areas of performance, efficiency, safety, and productivity for subsonic aircraft. The focus includes operational restrictions that create barriers to increased productivity of airline operations and the sale of aircraft in the global market as well as leading-edge, cost-effective control, guidance, display, sensing, automation, operating and human factors technologies and their integration to reduce these barriers. This research involves university, industry, operator and regulatory communities, to facilitate deploying these technologies in commercial products.

Objective (2): Develop and validate technologies necessary to enable low-altitude, nap-of-the-Earth, rotorcraft flight for military or civil operations with significantly increased flight safety and, at increased speeds and lower altitude, to enhance survivability. Both military and civil helicopter missions require flight close to terrain and obstacles with high pilot workload. To enhance safety, the program will develop and integrate forward looking sensor and digital terrain data; integrated pilot's display of sensor and guidance information; and human-centered flight path management concepts. The program will use piloted simulation and in-flight experimentation, in a partnership with operator and industry customers, for the development and validation of the newly developed technologies.

Objective (3): Enable U.S. leadership in high-performance aircraft flight control systems performance through the development and validation of innovative systems, cost-effective analysis, synthesis, testing and flight simulation technology. This program includes advanced control systems design and analysis modeling to increase aircraft performance and safety, while increasing the efficiency of flight research. Emphasized are flight-demonstrated results, leveraged on the major flight research projects, conducted in cooperation with the industry and DoD.

Objective (4): Improve the understanding of fundamental principles and develop new methods, and concepts to advance guidance, controls, human factors, information systems, and aviation sensors to enable significant improvements in aviation system mission capability, efficiency, and safety. This program will develop and demonstrate models and analytical methods for predicting human and system performance. operational procedure methods, and novel concepts for applying these models and methods.

Flight systems: extend the world-class capability in flight systems by discovering, developing, and demonstrating in flight, high-payoff critical technologies. The associated design databases, and design methods are effectively transferred to industry and DoD for the development of safe and superior U.S. civil and military aircraft.

Objective (1): Advance fundamental understanding of ice buildup on flight vehicles using analytical and experimental capabilities and develop and assess ice removal or prevention techniques to assure safe flight in icing conditions. Planned activities include analytical modeling and experimental research to support industry's stated needs for accurate simulation of icing conditions, and fundamental research to understand and model the ice accretion process. Industry uses these models to predict ice accretion shapes, estimate aerodynamic performance losses caused by the ice contamination, and to assess the need for ice protection to prevent ice build up. The approach meets the requirements of the primary customers, airframe and engine manufacturers. The research activities use wind tunnels, computer codes, and flight vehicles in a coordinated manner to assure that design methods, data bases and test methods integrate with flight vehicles providing the understanding for the specific technology developments.

Objective (2): Develop and validate advanced concepts, design methods and criteria, and test methods for enhanced maneuverability and controllability of high performance aircraft throughout an expanded operational flight envelope. Studies have shown that enhancing maneuverability and controllability Over an expanded operational envelope provides significant advantages in air combat. Realizing this potential in future combat aircraft requires the development and validation of a number of technologies. Specifically, experimental methods for measuring the complex high angle of attack aerodynamics facilitate the validation of computational tools. Advanced control effectors with high utility throughout the expanded flight envelope and control laws that integrate these effectors providing desired flying characteristics will be developed. The approach involves the integration of wind tunnels and computer codes for aerodynamic studies, piloted simulations for flight dynamics and flight control research. and specialized research aircraft for flight validation. The NASA research centers coordinate these activities with emphasis on effective transfer of program results to industry through periodic focused symposia and site visits.

Objective (3): Develop and demonstrate integrated airframe and propulsion controls technology enabling efficient and effective design of controllers for advanced configurations with highly coupled airframe and propulsion dynamics. Technologies which enable new integrated designs to control the dynamic airframe/propulsion coupling are a significant issue in high-performance aircraft. This program provides the technologies and demonstrates them. Potential application of this technology includes hypersonic vehicles, powered lift configurations. and multi-axis thrust-vectored vehicles. This research program involves a coordinated series of wind tunnel, analytical, and piloted simulator studies conducted jointly with industry. Flight tests on a testbed vehicle incorporating advanced controls will demonstrate and validate the design methods.

Objective (4): Develop flight test techniques, methods, sensors, and instrumentation to maintain a world-class flight research capability. Activities involve enhancing the capabilities for superior flight research, including advanced measurement systems and testbed aircraft. Multidisciplinary design and analysis tools under development in conjunction with the measurement systems will support flight research. Testbed aircraft makes the evaluation of advanced concepts and technologies for all vehicle classes possible. This includes "smart" actuators, optical flight and engine control sensors, satellite based vehicle positioning, aerodynamic experiments and laser air data systems. Several universities support research focused on the technical issues of flight testing.

Systems analysis: establish a world-class systems analysis capability that provides timely guidance for prioritizing research and development investments, through the identification of critical technologies for future systems and the tradeoffs among competing concepts. The cornerstone is the continuing development of superior aircraft design methods that will be used by NASA and U.S. airframe and propulsion industries to guide research and improve the design process.

Objective (1): Complete rapid and accurate system study assessments of twenty-first century transport concepts, advanced subsonic propulsion systems, rotorcraft, and flight research concepts, and define the research and experiments needed. Systems analyses help to understand the relative merits of alternative approaches using a consistent basis for evaluation. Such analyses can evaluate advanced technology and alternate concepts when integrated into a mission-capable aircraft system rather than in isolation. Either NASA or the industry perform studies, based on the expertise needed. Computer-based design tools help to develop baseline aircraft models from which parametric changes enable evaluation of different technologies or missions, component performance levels, and the establishment of sensitivities and concept feasibility.

Objective (2): Develop, validate, and transfer to industry advanced conceptual and preliminary design methods and systems for aircraft that will revolutionize the design process (cut cost and time in half). The conceptual/preliminary design process for aircraft and propulsion systems would use these methods to improve the process, where a better product can be designed and costly engineering changes avoided, thereby reducing the dominant source of aircraft development time. These design methods incorporate advances in decision-support (optimization), user interfaces, and flexibility to assess widely-varying concepts. They also increase the level of disciplinary breadth and accuracy available during the conceptual/preliminary design process and provide key information normally available later in the design cycle. Development is accomplished within NASA and via university grants, with technology transfer a primary objective.

Hypersonics: Develop and demonstrate enabling technologies for twenty-first-century, airbreathing, aerospace planes that offer the operational flexibility, responsiveness, and economies to revolutionize U.S. access to space capabilities and for atmospheric-cruise vehicles that satisfy mission requirements for rapid global response.

Objective (1): Advance technologies and improve data bases for supersonic combustion ramjets (scramjets). A 24-month contract with the Russian Central Institute of Aviation Motors (CIAM), will augment the U.S. scramjet data base with results from both ground tests and a flight test at Mach 6.5. Ground-based tasks by NASA researchers and facilities in the Mach 4 to range will also enhance the data base and improve the performance potential of scramjets. Conceptual work on the advanced turboramjets will advance the technology base for "low speed" (Mach 0 to 4) propulsion for hypersonic vehicles. Systems

analyses will continue to keep all the work focused on high-payoff tasks (since hypersonic vehicles are especially sensitive to technology integration).

Objective (2): Obtain critical data for hypersonic boundary-layer transition. Flight tests will achieve great economies by "piggy-backing" onto a Pegasus launch vehicle to fly an instrumented wing-glove by FY 1997.

In addition to the six disciplines. the R&T Base program began an Advanced Concepts effort in FY 1994 to provide a mechanism for rapid identification, development and transfer of potentially high payoff concepts to our customers. This program is the largest-ever solicitation of breakthrough ideas from the aeronautics community and encourages partnerships between industry, universities, and government agencies to take! advantage of their cumulative strengths. Prior research programs have either paced improvements to existing technology areas or focused program improvements. This effort focuses on advanced concept development of aeronautical systems or subsystems for which a medium-to-high risk and potential high-payoff opportunity is foreseen. The program seeks creative and innovative ideas for multidisciplinary concepts and encourages government, industry, and university staffs to cooperate in the research. NASA Research Announcements identify research opportunities, with proposals solicited for either a Research Analysis (maximum one year to establish the feasibility of a large-scale development program) or Research Project (maximum three years to provide advanced concept validation). In FY 1994, the program awarded six Research Projects and ten Research Analyses.

MEASURES OF PERFORMANCE

Aerodynamics

Validate aircraft design method June 1994	Experimentally validated the cooperative business jet design which was developed in a cooperative arrangement with Lear corp., through analysis of wind tunnel data.
Validate the computational methods in transonic flow September 1995	Evaluate a new computer code to compare calculated Reynolds number effects for a wing and a wing/body configuration with experimental data.
Assess tiltrotor noise alleviation - June 1996	Complete a computational method for noise control and evaluate the method with experimental data.
Develop a new framework for transition prediction December 1996	Complete a new industry standard (accepted) for predicting the transition of air flow from laminar to turbulent.

Propulsion and Power	
Thermocouples evaluated for use in a high-temp and pressure environment June 1994	Demonstrated thin film thermocouples on ceramics in high-temperature and pressure gas stream providing new instrumentation for advanced engine materials research.
Flight demonstration of a fiber-optic based propulsion/flight control system September 1994	Completed a flight test evaluation of fiber-optic flight control sensors and propulsion control sensors and verified measurements are the same as those from the electrical control sensors.
Transfer of dynamic analysis code for helical gears June 1995	Validation of the first release of a dynamic analysis code for non-empirical prediction of gear life and noise levels, and transfer of codes to industry users.
Transfer low NOx simulation codes to industry September 1995	Hold industry workshop to instruct users and transfer the low-emission gas turbine combustors.
Deliver a preliminary conceptual analysis of the Numerical Propulsion System Simulator March 1996	Deliver the Numerical Propulsion System Simulator to the propulsion and aircraft industry and ensure all critical capabilities are fully functional as judged by the NASA/Industry cooperative technical focus group.
Materials and Structure	
Demonstrate crash worthiness of General Aviation composite aircraft structures September 1994	Structural integrity and post crash volume were maintained in a full scale General Aviation aircraft test and criteria were met.
Demonstrate weight reduction fuselage panels - September 1995	Validate structurally efficient wing and fuselage concepts which would allow for a 15% wing and fuselage weight reduction.
Evaluate the noise reduction identifled which enable 6 dB September 1996	Demonstrate through experimental testing that sufficient concepts show potential of innovative rotor noise reduction relative to conventional concepts rotor systems without sacrificing aerodynamic performance.

Demonstrate strength and toughness of emerging aluminum alloys March 1996	Confirm that data from validation coupon testing predicts new aluminum alloys produced by novel intermediate rate solidification process.
Demonstrate accuracy of flutter prediction September 1996	Demonstrate through benchmark tests that calculations of transonic wing flutter are accurate to within 5% through the inclusion of viscous effects.

Controls. Guidance and Human Factors

Conduct wake vortex wind tunnel and flight experiments employing airborne LIDAR March 1994	Experimental data obtained from flight test using LIDAR matched (within one standard deviation) the calculated data.
Demonstrate feasibility of DGPS in support of Category II & III approach and landing September 1994	Carrier phased based use of DGPS was demonstrated with a system accuracy of 1.2 meter on final approach.
Demonstrate computer-aided low-altitude guidance September 1995	Identify and implement methods for increasing pilot awareness and reducing human error using active sensor augmentation.
Demonstrate real-time system for measuring level of pilot awareness December 1994	Based on psycho-physiological data, conduct pilot evaluation and system performance measures from flight tests and identify methods for increasing pilot awareness and reducing human error.
Complete field evaluation for extended terminal area air traffic controller aids September 1996	Evaluate concepts, technologies, and procedures which will support the FAA development plans.
Demonstrate use of computer-controlled engine thrust September 1996	Using an MD-11 aircraft, demonstrate the ability to safely land in a simulated emergency, using engine thrust computer control only.

Complete Civil Tiltrotor terminal September 1996	Obtain human performance and workload data from a simulated tiltrotor area simulation cockpit in a number of terminal area scenarios.
Flight Systems	
Demonstration of propulsion only December 1993	Demonstrated safe recovery from upset attitudes and landing, as well as flight controls using engine only for control of an F-15 aircraft.
Complete post-stall X-31 flight June 1994	Close-in-combat flight testing was completed using the X-31 experimental evaluation aircraft. KTL ratios of greater than 10 to 1 were demonstrated.
Validate 2-dimensional ice accretion prediction code September 1995	Evaluate an advanced ice accretion computer code and transfer to industry through instructional workshops.
Complete flight evaluation of advanced aerodynamic control for greater air combat maneuverability September 1995	Measure engineering data and make available for comparison with computational and simulator predictions of actuated forebody strakes for vehicle control at high angles of attack.
Initiate assessment of axisymmetric vectoring exhaust nozzles on the F-15 research aircraft September 1995	Complete F-15 aircraft modifications and clear the aircraft for flight by the Air Worthiness and Flight Safety Review board.
Complete flight assessment of and aerodynamic control concepts September 1996	Identify and qualify strength and weaknesses of advanced control schemes, which can enhance thrust vectoring fighter aircraft performance and enable tailless configurations, using the F-18 High Angle-of-Attack Research Vehicle.
Demonstrate operability and real-time performance optimization of thrust vectoring nozzles September 1996	Using the F-15 research aircraft. quantify performance of "care-free" engine and nozzle operation throughout the flight envelope and document performance improvements.
Initial flight evaluation of neural network flight controls - September 1996	Flight control performance on the F-15 research aircraft will equal or exceed today's conventional flight control system performance.

System Analysis	
Flexible synthesis architecture approach selected September 1995	Select best approach and initiate conversion of design codes.
Hypersonics	
Pegasus wing-glove completion July 1995	Complete wing-glove and data system - to be mounted on the next available Pegasus for FY 1996/7 flight.
University grant reviews September 1995	Review FY 1995 results and prepare for the final year at the set of three universities.
Mach 6.5 scramjet ground test February 1996	Demonstrate flight-test system performance/operation in a simulated flight environment.
Mach 6.5 scramjet flight test November 1996	Obtain a full set of flight data on the performance and operability characteristics of a basic. medium-sized scramjet.

ACCOMPLISHMENTS AND PLANS

Significant accomplishments for FY 1994 in the area of aerodynamics include the validation of a business jet design method based on analysis of wind tunnel data -- a cooperative developmental arrangement with Lear Corporation. Pressure sensitive paint technology for measurement of wind tunnel data was developed into a portable system for use in multiple wind tunnel facilities. Airload and acoustic data for a modem helicopter rotor were documented and the database is available and in use by the rotorcraft industry. *An* infrared measurement technique for accurately characterizing boundary layer transition was developed, which will greatly enhance research in this high-priority area. In FY 1995. computational methods for transonic flow will be validated by comparing calculated Reynolds number effects for two configurations with experimental data. A real-time off-site connection for customers to remotely observe and interact with NASA personnel during wind tunnel testing and immediately receive their data will be developed. Three dimensional non-intrusive acoustic survey instrumentation will be developed for wind tunnel application. Advanced transition prediction methods for studying laminar flow at subsonic and supersonic conditions will be developed and new turbulence models will be adapted for industrial codes. No funding is included for a joint rotorcraft program with the *Army.* NASA continues to discuss this possibility with the *Army,* and will realign funds within the aerodynamics discipline to match the *Army's* contribution if an agreement is reached. In FY 1996, a new framework for transition prediction will be completed with the goal of becoming the industry standard for laminar flow analysis. Computational methods for tiltrotor noise control will be completed and evaluated against experimental data.

In the area of propulsion and Dower, the FY 1994 significant accomplishments include the evaluation of thin film thermocouples in high-temperature and pressure gas stream, demonstrating a significant new capability for advanced engine materials research. A three-dimensional multi-stage viscous analysis computer code was validated, based on a large low-speed axial compressor

database, that will accelerate research and development of multistage engines. In the area of low-emission combustors, advanced concepts were evaluated resulting in a database of exhaust gas constituents for atmospheric assessment of small engines. Flight test evaluation of a fiber-optic flight and propulsion control sensors was completed and verified to be the same as those from electrical control sensors. In FY 1995, lower cost and more reliable propulsion sensors will be developed which integrate optics and microfabricating technologies. Real-time displays of non-intrusive engine measurement systems will be developed using lasers, electro-optical devices, and other technologies. A workshop will be conducted to transfer and provide instruction to industry on the use of low-emission gas turbine combustor computer codes. Also, a dynamic analysis code for non-empirical prediction of gear life and noise level will be transferred to industry. In FY 1996, NASA will deliver the fully functioning Numerical Propulsion System Simulator to the propulsion and aircraft industry after evaluation by a joint government/industry technical focus group.

FY 1994 accomplishments in materials and structures include the evaluation of several new polymer formulations for high temperature application including single-crystal nickel aluminide and a diamond-like carbon film on ceramics. Parametric studies and analyses of the behavior of composite shells in buckling were completed. Full-scale crash worthiness testing was completed in which all criteria for crash worthiness of a General Aviation composite structures were met. In FY 1995, advanced concepts for efficient wing and fuselage concepts that should result in 15% weight reduction will be validated. Fatigue damage accumulation models for metal- and intermetallic-matrix composites will be validated. Viscoplastic models for complex structural alloys will be completed. And a national radial tire friction database for landing gear analysis will be completed. In FY 1996. noise reduction potential of innovative rotor concepts will be experimentally evaluated. Strength and toughness of emerging aluminum alloys produced by a novel solidification process will be demonstrated using coupon testing. Calculation of wing flutter at transonic speeds, with the inclusion of viscous effects, will be evaluated against benchmark tests.

Accomplishments in control. guidance. and human factors for FY 1994 include wake vortex experiments in the wind tunnel and in flight, using airborne LIDAR, which matched the calculated data within one standard deviation. Flight evaluation of a new flight management system linked to air traffic controller automation aids was completed. A system accuracy of 1.2 meters was demonstrated, with a digital global positioning system (DGPS) that will support future Category II & III approach and landing conditions. New mathematical methods which assess software reliability were successfully demonstrated in a joint effort with Boeing in evaluating their B-777 navigation system. Color helmet-mounted display and low-noise approach flight profiles were evaluated using the UH-60 rotorcraft airborne laboratory. In FY 1995. a real-time system for evaluating pilot awareness will be demonstrated based on actual flight data to identify means of increasing pilot awareness and reduce human error. A computer-aided low-altitude guidance system will be demonstrated and evaluated in terms of being able to increase pilot awareness and reduce errors. Full-scale testing of a tiltrotor advanced technology blades will be completed in the NASA 80x120 foot wind tunnel to assess noise and performance in support of the civil tiltrotor program. In FY 1996, field evaluations which support the FAA's plans of extended terminal area air traffic controller aids will be completed. Using an MD-11 aircraft, computer-controlled engine thrust in a simulated emergency will be demonstrated. Also, human performance and pilot workload will be assessed for a Civil Tiltrotor terminal area simulation in the Vertical Motion Simulator.

In the area of flight systems, FY 1994 accomplishments include completion of propulsion-only flight controls on an F-15 aircraft that demonstrated safe recovery from upset attitudes followed by safe and controlled landings. The X-31 Enhanced Fighter

Maneuverability aircraft, using thrust vectoring technology, completed its military utility assessment and showed kill ratios of 10 to 1 in close-in-combat engagements. Excellent correlation was found between the calculated and the actual flow around the F-18 High-Alpha Research Vehicle (HARV) and excellent effectiveness has been demonstrated using the aircraft's thrust vectoring control system. In FY 1995. a computer code which can design and analyze thermal ice protection systems will be made available to industry and a joint NASA/FAA/industry program to address ice induced tail plane stalls will be initiated. Flight evaluation of advanced aerodynamic control using forebody strakes for greater air combat maneuverability will be completed using the F-18 HARV. F-15 aircraft modifications (which include thrust vectoring) will be completed and cleared for flight by the Air Worthiness and Flight Safety Review Board. In FY 1996, flight research will include flight assessment of thrust vectoring and aerodynamic control which would enable tailless aircraft configurations. Using the F-15, operability and real-time performance optimization of thrust vectoring will be demonstrated, and finally initial evaluation will begin on the flight control performance of neural network controls.

System analysis accomplishments include the completion of oblique all-wing configuration and mission studies and the assembly of an aerodynamic and structural model. Studies of laminar flow systems for supersonic and business jet applications were completed as well as a projection of propulsion needs for 2005. A prototype of an expert system to facilitate design of propulsion nozzles was completed and successfully demonstrated. In FY 1995. studies of alternative supersonic transport configurations and an assessment of the economics of long range supersonic air service will be completed. A flexible synthesis architecture approach will be selected for the system analysis design codes. This effort will continue into FY 1996 with thorough system study of innovative large (800 passenger) aircraft systems.

Accomplishments for hypersonics consist largely of results for the joint NASA/DoD National Aero-Space Plane (NASP) program (reported under Transatmospheric R&T) and from the previous NASA R&T base work. NASA conducted thermomechanical tests of large structures of advanced materials (such as titanium-aluminide composites, carbon-carbon, etc.) provided unique research data, and also conducted initial tests for hypersonic boundary-layer research on a rocket-powered Pegasus launch vehicle. Wind-tunnel tests utilizing smaller-scale, scramjet models at Mach 4 to 8 conditions improved the data base on injector technology and non-intrusive diagnostic techniques. Fundamental tests on scramjets at Mach 10 to 17 provided data on fuel-air mixing and combustion as well as on coupling computational with wind-tunnel techniques for improved data interpretation. In the future, the Russian CIAM contract will produce flight-article designs and component fabrication in FY 1995. ground-test data in FY 1996, and flight-test data in early FY 1997. The conceptual work on advanced turboramjets will refine cycle definition and the total system in FY 1995 and FY 1996. then provide small-scale hardware for tests in late FY 1997. Ground tests of scramjets will feature Concept Demonstration Engine model testing at Mach 5 and Mach 7. with complementary subscale tests in Langley facilities in FY 1995 and FY 1996. Other testing in FY 1995 and 1996 will refine fuel-injector design and associated diagnostics, with potential improved concepts proof-tested in FY 1997. Structural tests of existing NASP hardware will include both the carbon-carbon elevon and actively cooled panels of advanced design/materials in FY 1995. An instrumented wing-glove will be fabricated in FY 1995 for flight on a Pegasus by FY 1997. Systems studies will feature integration of final NASP experimental results into the correlation and upgrading of hypersonic design and analysis tools in FY 1996.

BASIS OF FY 1996 FUNDING REQUIREMENT

SYSTEMS CHN(PROGRAMS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	Page Number
High-performance computing and communications	63,600	76,100	75.200	SAT 4-17
Advanced composite technology	25,700	24,300	--	SAT 4-22
Numerical aerodynamic simulation	48,100	46,200	48,100	SAT 4-25
High-speed research..	197,200	221,300	245,500	SAT 4-29
Advanced subsonic technology	89.300	125.800	188.400	SAT 4-35
To	423.900	493.700	557.200	

BASIS OF FY 1996 FUNDING REQUIREMENT

	FY 1994	FY 1995	FY 1996
		(Thousand of Dollars)	
High performance computing and communications...	63,600	76.100	75.200

PROGRAM GOALS

Studies have shown that high-performance computing technologies have a tremendous positive impact on job creation, economic growth, national security, world leadership in science and engineering, health care, education. and environmental resource management, as well as enabling the missions of many Federal agencies. The goals of the NASA High-Performance Computing and Communications (HPCC) Program are to accelerate the development, application and transfer of high-performance computing technologies to meet the engineering and science needs of the U.S. aeronautics. Earth science. and space science communities and to accelerate the implementation of a National Information Infrastructure.

STRATEGY FOR ACHIEVING GOALS

The HPCC program goals are supported by five specific objectives:

1) Develop algorithm and architecture testbeds that are able to fully utilize high-performance computing concepts while increasing end-to-end performance:
2) Develop high-performance computing architectures scalable to sustained TeraFLOPS performance:
3) Demonstrate HPCC technologies on U.S. aeronautics, Earth science, and space science research problems:
4) Develop services, tools. and interfaces essential to the National Information Infrastructure:
5) Demonstrate pilot programs in remote sensing data access, education, and aerospace design and manufacturing.

The NASA HPCC program consists of four vertically integrated projects. These projects are: the Computational Aerosciences (CAS) Project, the Earth and Space Sciences (ESS) Project, the Remote Exploration and Experimentation (REE) project and the Information Infrastructure Technology and Applications (IITA) project. The primary objective of the CAS project is to significantly shorten the design cycle for advanced aerospace products such as future high-speed civil transports. The ESS project strives to enable the comprehensive modeling of large scale, long duration phenomenology such as global climate change or galactic evolutionary processes. REE. which is being initiated in FY 1996, has the goal of developing and demonstrating a space-qualified, spaceborne computing architecture that requires less than ten watts per billion operations per second. The IITA component is made up of several interrelated components. The first is the Digital Libraries Technology component which aims to accelerate the development of the information technologies that will locate and distribute multimedia. digital information assets throughout the National Information Infrastructure. The second component is the applications of Remote Sensing Databases including digital imagery and environmental sensing data for nationwide communities, such as K-12 students and teachers, farmers. and land use planners. The last activity is the Education, Training, and Lifelong Learning component which is developing new tools and

techniques to improve science, mathematics, engineering, and technology education using advanced educational technology and the Internet.

NASA HPCC program was authorized by the High Performance Computing and Communications Act of 1991 and work began in FY 1992. In the first three years, much progress has been made towards solving "Grand Challenge" problems in science and engineering. Teams have been openly and competitively selected to address specific areas such as supersonic passenger aircraft simulation and global climate modeling. Major national computational testbeds have been established at Ames Research Center and Goddard Space Flight Center to support these teams and to evaluate evolving HPCC systems and to develop software tools to fully utilize these new computing platforms. In FY 1994, a new component was added to the NASA Program called Information Infrastructure Technology and Applications (IITA). This new activity strives to bring HPCC technologies to bear on "National Challenges" in: Education, Training, and Lifelong Learning; Health Care: Environmental Monitoring; Digital Libraries: Manufacturing and Design; and Access to Government Information.

The NASA HPCC program is planned and executed in cooperation with Federal agencies, industry, and academia to ensure that customer requirements and rationale are understood and to promote the rapid and effective transfer of technology products. Interagency collaboration is fostered through the National Coordination Office which has a full time staff to support the main HPCC coordinating body, the High-Performance Computing, Communications. and Information Technology (HPCCIT) Committee.

The implementation of the NASA HPCC program is mainly through coordinated activities at NASA field Centers. The overall NASA program is coordinated through the NASA HPCC Executive Committee composed of senior level managers from the major HPCC centers and representatives from the Headquarters "stakeholdei' offices, the Office of Aeronautics, the Office of Space Science, the Office of Mission to Planet Earth, and the Office of Education and Human Resources. The technical program is documented via a HPCC Program Plan that is updated annually. Multiple reviews are held during the program year to ensure the program is achieving its stated goals, and is staying within schedule and budget.

NASA has used senior executives from major U.S. aerospace companies to plan the Computational Aerosciences Project to best respond to customer requirements. In the summer of FY 1994, major revisions to the CAS program plan were initiated based on industry input to better transfer CAS technology projects to industry. These revisions included developing a NASA Research Announcement (NRA) targeted at design application work of interest to aerospace companies. This open and competitive solicitation has resulted in several contracts with U.S. aerospace companies. In addition, a new thrust was developed to facilitate the utilization of the existing computational infrastructure of the aerospace industry. The "distributed computing" initiative is embodied in an NASA Cooperative Agreement Notice (CAN) that was issued early in FY 1995. Awards will be made during calendar year 1995. Managers of the HPCC program continually visit and interact with industry leaders to better understand industry's critical needs for HPCC technologies.

The NASA HPCC program has significant involvement by outside participants who bring expertise and resources to achieve common goals. There are two categories of involvement -- Interagency Cooperative Programs and Cooperative Agreement Programs.

Interagency Cooperative Programs: The National Science Foundation (NSF), the Advanced Research Projects Agency (ARPA), and NASA jointly sponsor the NSF/ARPA/NASA Digital Library Initiative. Each agency has a designated manager as part of a joint management team. Also, NASA and NSF have sponsored a joint program for the evaluation of high-performance systems. This program, the Joint NSF/NASA Initiative in Evaluation (JNNIE), has been evaluating the performance of 22 significant software applications drawn from many Grand Challenge areas on eight HPCC computers from seven U.S. manufactures. The main objective of JNNIE is to determine the potential of Scalable, Parallel Computers (SPCs) and to evaluate the current baseline of SPC environments.

Cooperative Agreement Programs: NASA has initiated a number of major cooperative agreements including an award to a consortium lead by IBM for a HPCC testbed and awards for developing Internet applications and technology projects with Lockheed Missile and Space Company, WRC-TV, Bellcore, IBM. Computer Sciences Corporation, Loral Federal Systems, and The Analytical Sciences Corporation (TASC). Other cooperative agreements which represent significant partnerships between NASA and others have been established with Rice University for accelerating the transfer of simulation software tools to U.S. aerospace companies and with the University of Illinois, the Gulf of Maine Aquarium, Science Applications International Corp., ECOlogic Corp., Wheeling Jesuit College, The Childhood Project. Inc.. the Smithsonian Astrophysical Observatory, SENTAR, Inc., and BDM International for digital library technology and remote sensing data applications.

MEASURES OF PERFORMANCE

Install CAS Grand Challenge testbed scalable to 100 gigaFLOPS - July 1994	Demonstration of 10 to 50 gigaFLOPS sustained performance.
Establish program to provide public access to Earth and space science data over computer networks and programs - September 1994	Initiate 10 competitively selected projects by the end of FY 1994.
Demonstrate satellite-based gigabit applications using Advanced Communications Technology Satellite (ACTS) and associated ground terminals June 1995	Demonstration of 155 and 622 Mbps satellite/terrestrial connectivity among geographically distributed computational platforms.
Demonstrate initial remote sensing data base (RSDB) applications over the National Research and Education Network (NREN) September 1995	Demonstration of at least 8 projects for public access to remote sensing data over NREN. supporting hundreds of users.

Demonstrate multidisciplinary CAS & ESS applications on **10-50** gigaFLOPS testbeds - September **1996**	Demonstrate execution of CAS and ESS Grand Challenge applications at negotiated performance metric level.
Demonstrate end-to-end reductions in cost and time to solution for aerospace design applications on heterogeneous systems September **1996**	Demonstrate practical workstation cluster solutions at performance and reliability levels equivalent to FY **1994** vector supercomputers at **25%** of the cost.

ACCOMPLISHMENTS AND PLANS

In FY **1994,** the CAS project awarded a cooperative agreement to IBM Corporation to establish a major new testbed based on the **SP-2** parallel architecture at the NASA Ames Research Center. The NAS Parallel Benchmarks emerged in FY **1994** as a defacto industry standard for establishing system performance under NASA leadership. A major computational achievement included the development of multidisciplinary analysis codes for High-speed Civil Transport engine inlets by a team of NASA. Boeing, and the Universities of Indiana and Akron. Under the ESS project, significant progress was made in the modeling of turbulence and mixing in stellar objects, which produced the first generation of portable hydrodynamic codes for turbulent convection. Another significant ESS accomplishment was the simulation of anisotropies detected by the Cosmic Background Explorer (COBE) satellite, leading to further understanding of the Big-bang and very early universe. Finally, a very significant milestone was reached in FY **1994** when NASA and the Department of Energy announced the winner of a joint solicitation to deploy and demonstrate the first nationwide use of Asynchronous Transfer Mode **(ATM)** network technology over fiber optical networks supporting the Synchronous Optical Network (SONET) standard.

Within the IITA component in FY **1994,** a Cooperative Agreement Notice (CAN) was developed and published to solicit cooperative agreement and grant proposals for the development of innovative digital library technologies and for providing public access to remote sensing data over the Internet. **This** nationwide solicitation attracted **334** proposals. Out of this set. **26** projects have been selected for award. The NASA IITA program was also a partner in the review and selection process for the joint NSF/ARPA/NASA Digital Library Research and Testbed Initiative which resulted in **six** awards in September of **1994.** In addition, IITA educational outreach programs were initiated at seven NASA field centers involving many **K-12** students and teachers nationwide.

In **FY 1995,** the CAS project will develop high-speed civil transport (HSCT) analysis and optimization codes to perform medium fidelity HSCT modeling, and demonstrate accelerated aerospace design techniques. To better address critical needs of industry in the area of distributed computing. a Cooperative Agreement Notice for clustered workstation applications will be issued. In support of the National Research and Education Network, NASA will interconnect five of its research centers through a high-speed, **155** megabits per second network. Under the **ESS** project. NASA will demonstrate **Earth** and space science applications running in the **10-50** gigaFLOPS range. NASA will also demonstrate satellite-based Gigabit per second communication by linking the Advanced Communications Technology Satellite with terrestrial computer networks. Finally, advanced planning for the REE project will be initiated for a rapid **start** up of the project **in** FY **1996.**

In FY 1995, IITA will complete the negotiation and award of the grants and cooperative agreements solicited under the NASA Cooperative Agreement Notice issued in FY 1994. Many of the projects initiated will begin immediately to show results such as the installation of the kiosks for public access and display of remotely sensed data at the Houston Museum of Natural History, and the demonstration over the Public Broadcasting System of the IITA supported program "Live from Antarctica". In addition, two more Cooperative Agreement Notices will be issued. The first, for Education, Training and Lifelong Learning in Aeronautics, will be issued in early FY 1995 with projects initiated by mid-summer 1995. The second, which will be a revision of the FY 1994 CAN for public access to remote sensing data over the Internet, will be released late in the third quarter of FY 1995 with technical work to start early in 1996.

In FY 1996, the NASA HPCC program has many major accomplishments planned. These include: (1) demonstrating the interoperability between independently managed networks that are based on asynchronous transfer mode (ATM) technology supplied by multiple vendors; (2) demonstrating portability and scalability of software component tools to teraFLOPS systems; (3) demonstrating multidisciplinary aeroscience applications on 10-50 gigaFLOP testbeds; (4) demonstrating end-to-end reductions in cost and time to solution for aerospace design applications on heterogeneous systems; (5) demonstrating cost effective high- performance computing at performance and reliability levels equivalent to FY 1994 "Vector" supercomputers at 25% of the capital cost; (6) demonstrating multidisciplinary Earth and space science applications on 10-50 gigaFLOP testbeds; (7) establishing a 50-100 gigaFLOP Earth and space science testbed; (8) establishing a second set of applications of Remote Sensing Databases over the Internet by traditionally underserved communities; (9) establishing a second set of projects for developing digital library technologies to expedite locating, retrieving, and delivering digital information over the Internet; and (10) demonstrating the results of the first round of applications projects established in FY 1994 and FY 1995 for accessing Remote Sensing Data over the Internet.

	FY 1994	FY 1995	FY 1996
	(Thousands of Dollars)		
Advanced composites technology.....	25,700	24,300	--

Pages missing from originals. Printed from Internet website: http://www.hq.nasa.gov/office/budget/fy96/sat_4.html, November 22,2004

PROGRAM GOALS

The goal of the Advanced Composites Technology (ACT) program is to increase the competitiveness of the U.S. aeronautics industry by putting the commercial transport manufacturers in a position to expand the application of composites beyond the secondary structures in use today to wings and fuselages by the end of this decade. Industry's resistance to using composites is one of economics. While the current demonstrated level of composites technology can promise improved aircraft performance and lower operating costs through reduced structural weight, it does so with increased manufacturing costs, currently twice the cost of aluminum. The goal of this program is to verify composite structure designs that will have acquisition costs 20-25% less and weigh 30-50% less than an aluminum aircraft sized for the same payload and mission.

STRATEGY FOR ACHIEVING GOALS

Several candidate materials, concepts, and fabrication methods that offer the potential for cost-competitive composite structures were identified during Phase A which was completed in FY 1992. Since that time, tests on these materials coupons, small panels and elements, and fabrication demonstration articles provided the data necessary to focus the program on the most promising technologies: stitched dry fiber/resin transfer molding, textile preforms, and automated fiber placement. During Phase B, these techniques are being applied to construct several large benchmark components. These components serve a two-fold purpose. First, they provide test data of their ability to undergo the aerodynamic and pressure loads encountered by commercial transports. Second, they provide data relating to manufacturability and cost. By the completion of Phase B, a wing stub box for a 200- passenger aircraft and large panels representative of the crown, window-belt, and keel areas of large transport aircraft will be developed and tested. The wing concept exploits through-the-thickness stitching of dry fiber material and resin transfer molding, and the fuselage will be fabricated by a combination of automated fiber placement and textile preforms. NASA's Langley Research Center (LaRC) is developing this technology in conjunction with industry by contracting task orders for specific portions of the development, utilizing its own facilities and capabilities where possible. For example, the wing stub box was manufactured by McDonnell Douglas and has been shipped to LaRC for strength testing in the engineering lab. Fuselage panels fabricated by Boeing are being pressure tested in LaRC's Combined Loads Testing (COLTS) facility.

With the completion of Phase B in FY 1995, the results and knowledge relating to composite wings that were accumulated during the ACT program will be transferred to the composites element of the Advanced Subsonic Technology program to provide the high level of emphasis required for the design, construction and test of a full-scale composite wing. Technology efforts related to the fuselage will be transferred into the Materials and Structures R&T element of the base and will continue to be examined. This redirection within the NASA aeronautics composites efforts is an important step in ensuring that the U.S. industry has the technology for a strong competitive position in the international aviation market.

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MEASURES OF PERFO

Fabricate and test window-belt panels - June 1995	Establish cost effectivedesign and manufacturing process, at least 20% cheaper than the baseline aluminum structure and 30%lighter, and demonstrate by test, fuselage components with strength. stiffness, damage tolerance and repairability at least equal to that of baseline aluminum structure.
Fabricate semispan wing box June 1995	Establish cost effective design and manufacturing process, at least 20% cheaper and 30% lighter than the baseline aluminum structure with greater stiffness (requiredfor higher aspect ratio wing designs used to achieve improved aerodynamic efficiency in commercial transports) and equal load carrying capacity to that of baseline aluminum structure.
Test semispan wing box September 1995	Perform strength. stiffness, damage tolerance and repair tests on wing stub box to verify capability of the load carrying portion of a 200-passenger commercial transport wing requiring greater stiffness than the baseline aluminum structure.

ACCOMPLISHMENTS AND PLANS

In FY 1994, the advanced composites technology program made significant strides along the path to full-scale component assembly and verification. The progress centered on the production and testing of subscale components both in the wing and fuselage areas. Fuselage keel panels made of laminated composite skins co-bonded to a composite honeycomb core were manufactured and strength tested by a team consisting of Boeing engineers and their subcontractors as well as NASA researchers. Cost analysis software was also developed. The panels met ACT cost and weight goals. Its implementation in the analysis of the engineering and manufacturing process led to a focus on honeycomb core sandwich material as the material of choice for the fuselage side panels as well as the keel. In the wing area, McDonnell Douglas and their subcontractors along with their NASA team members manufactured a number of "proof of tooling" wing cover panels to gain confidence in the resin film infusion (RFI) process of hardening dry fabric layers stitched together for extra strength. Once the process had been perfected, a wing stub box, an inboard portion of wing structure with stiffened upper and lower panels, was fabricated and assembled and prepared for testing. The stub box met ACT cost and weight goals.

The effort for FY 1995 is a continuation of the FY 1994 effort and completion of the program. The recently developed wing stub box will be tested to assure that it meets strength and stiffness requirements. Development of a large capacity stitching machine will begin with Ingersoll Rand. This multi-head computer controlled sewing machine will be a prototype capable of stitching together the dry fabric layers of a full scale 200+ passenger airplane wing. The level automation will help meet the ACT manufacturing cost goals. In the fuselage area the effortwill focus on the low cost fabrication and subsequent testing of window-belt panels. This fuselage cutout must take loads and provide a secure pressure seal.

Phase B of the ACT program will conclude at the end of FY 1995. The knowledge obtained from the ACT program will be transferred and continued in the composites element of the Advanced Subsonics Technology program.

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Numerical aerodynamic simulation	48.100	46.200	48.100

PROGRAM GOALS

The Numerical Aerodynamic Simulation (NAS) goal is to enable the simulation of an entire aerospace vehicle system within one to several hours by the year 2003. For the past fifty years, the United States has been the undisputed leader in global air transportation. Now foreign interests dominate the general aviation industry and are making inroads into the commuter aircraft market. European and Far Eastern nations are applying significant resources needed to obtain a greater share of the subsonic transport aircraft market. The NAS program provides the Nation's aerospace research and technology community a high-performance, computing capability that is recognized as a key element of NASA's aeronautics program.

STRATEGY FOR ACHIEVING GOALS

The objectives of the NAS program were carefully selected to assist the U.S. Aeronautics community in its quest to continue dominance of the world-wide aircraft market. These objectives are: (1) act as a pathfinder in advanced, large scale computational capability through systematic incorporation of state-of-the-art improvements in computer hardware and software, (2) provide a national computational capability, available to NASA, DoD, industry, other governmental agencies and universities, as a necessary element in ensuring continuing leadership in computational fluid dynamics and related computational aerospace disciplines, and (3) provide a strong research tool for the Office of Aeronautics. The benefits of numerically simulating a complete aerospace vehicle system are substantial and include an accelerated vehicle system development cycle, reduced vehicle development cost and risk. and an increased vehicle operation efficiency. The computational requirements needed to simulate a complete aerospace vehicle system are approximately 200 times greater than that which is available and affordable today. At least a sustained teraFLOP computing capability is required. Scalable parallel systems offer the greatest potential for achieving this goal.

NASA Headquarters is responsible for overall program direction and assessment. Program implementation rests with the Ames Research Center (ARC) NAS Systems Division which provides technical and program management. Contractors provide system development and computational support services.

The NAS facility provides the tools and resources for obtaining solutions to problems which may be intractable on less than state-of-the-art computer systems, including solutions to the Navier-Stokes equations, (enabling performance analysis predictions for complex aircraft geometries). In order to ensure this degree of computational capability, the NAS program continues to implement the following efforts: (1) acquire pathfinding, state-of-the-art, high-speed processors (HSPs): (2) provide a uniform, balanced, user-friendly system with equivalent capabilities for local and remote users: (3) maintain an auxiliary processing center for secure processing: (4) research existing parallel architectures and incorporate them into future generations of the NAS: (5) develop a hardware and software environment for prototyping and testing of computers, networks, storage devices, workstations and graphic output devices: and (6) continue to research and enhance an increasingly sophisticated system of hardware/software tools and

environments to assist the user in performing computational fluid dynamics (CFD) tasks efficiently. The NAS facility serves as a National testbed for new hardware and software products for the United States computer/communications industry.

The NAS program will continue its practice of entering into a variety of cooperative agreements to advance its pathfinding goals. These cooperative agreements are anticipated to continue with industry, universities, and agencies of the Federal government. These agreements will be used to encourage the development of new technology and to invest in basic research in computer science. As of September 1994, NAS had memorandums of understanding with Intel Supercomputer Systems Division. Convex. National Energy Research Supercomputer Center (NERSC). Maximum Strategy, Advanced Research Project Agency (ARPA) and Sandia. NAS and Intel were able to rewrite portions of Intel's Paragon operating system and improve the reliability and efficiency of the Paragon. Convex, in collaboration with NAS, was able to transfer the highest performing hierarchical mass storage system to the computer industry and market it to the general public. Research and development with ARPA fostered the emergence of high-performance computer peripherals such as Redundant Array of Independent Disks (RAID) storage devices.

MEASURES OF PERFORMANCE

Upgrade remote network backbone to T3 FY 1994, Qtr 4	Upgrade long-haul communication network capability from T1 (1 megabit per second) to T3 (45 megabits per second).
Upgrade local area network FY 1995. Qtr 3	Increase throughput from 1 gigabit/second to 16 gigabits/second while decreasing maintenance costs.
Acquire and install a distributed network storage system, Mass Storage 3, that replaces the current CPU-based system with at least double the capacity FY 1996. Qtr 3	Evaluate disk and network technology for non-front-end solution with the objective to improve access time, and at the same time, increase capacity to at least double the current 1.6 terabyte capacity.
Acquire and install High Speed Processor 4 FY 1997, Qtr 2	Deliver to the NAS community a four-fold increase in computational hours.
Acquire and install Mass Storage System 4 FY 1999, Qtr 2	Increase disk capacity six-fold and increase tape capacity by a factor of 10.
Acquire and install High Speed Processor 5 FY 2000. Qtr 2	Deliver to Aeronautics community a computing system capable of simulating a complete aerospace vehicle system.

Provide the Nation's aerospace research and development community a high-performance, operational computing system capable of simulating an entire aerospace vehicle system within one to several hours
FY 2003

Demonstrate a complete vehicle system simulation within several hours.

OMPLISHMENTS AND PLANS

NAS sustains its balanced system software and support for the HSPs through a continuous upgrade process. The third high-speed processor (HSP-3), a 16-processor Cray C-90, was placed into operation in March 1993. In September 1993, the NAS memory was upgraded from 256 megawords to one gigaword, making it the largest configured Cray C-90 in the unclassified world. The four-fold increase in computational hours is now available to the NAS community. The funding constraints in FY 1994 and FY 1995 and increased cost of semiconductor memory will delay high-speed processor (HSP-4) installation to FY 1997. The HSP-4 is expected to provide a four-fold increase in capability. The installation of our last planned high-speed processor (HSP-5) is scheduled for March 2000. The aerospace community will have 18-24 months to utilize and evaluate the system and to complete its goals prior to project completion in FY 2003.

NAS provided for an upgrade to the Aeronautics long-haul communications network (AERONet) in FY 1994. Connections between Ames Research Center (ARC) and Langley Research Center (LaRC) and ARC and Lewis Research Center (LeRC) were increased from 6.16 megabits/second to 45 megabits/second and those between ARC and the end user were increased from 56 kilobits/second to 1.544 megabits/second. AERONet currently provides a 100-fold increase in throughput and is planning another three-fold increase by the last quarter in FY 1995.

Scalable parallel system technology is being advanced under the High-Performance Computing and Communications program. Evaluation of these parallel architectures and algorithms is progressing favorably in the NAS facility, where critical issues associated with ensuring desired performance and software development are key to transitioning the technology into next generation systems.

To keep storage capacity consistent with increasing high-speed processor output, the NAS facility now has Storage Technology tape drives, which have increased the NAS storage capacity to 45 terabytes. Also installed were two Convex mass storage systems increasing on-line disk capacity to 1.6 terabytes. In FY 1995, we intend to double the capacity of disk and increase the capacity of tape ten-fold. One cost-saving feature currently being evaluated in the NAS program is the use of direct network connection mass storage to more efficiently access and retrieve data. Disk capacity is expected to double every year and tape capacity to increase ten-fold every four years.

The NAS will continue as a national computational capability available to the U.S. aeronautical community (i.e. NASA, DoD, industry, other Government agencies and universities). The NAS provides support to LeRC and Pratt & Whitney to develop and validate multidisciplinq, multistage compressor computational tools to halve the design time of large commercial aircraft engines. These tools have also led to a 1.5% reduction in specific fuel consumption.

The number of user accounts will be maintained at its current level of about 1400, representing some 400 projects nationwide, continuing the diverse use of the NAS systems by the U.S. aeronautical community.

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996
High-speed research	197,200	221,300	245,500

PROGRAM GOALS

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The High-speed Research (HSR) program has the goal of developing the technologies that industry needs to design and build an environmentally compatible and economically competitive high-speed civil transport for the 21st century. The technology developments are to reach an appropriate stage of maturity to enable an industry decision on aircraft production in the year 2001.

Studies have identified a substantial market for a future supersonic airliner -- or high-speed civil transport (HSCT) -- to meet the rapidly growing demand for long-haul travel, particularly across the Pacific. Over the period from 2005 to 2015, this market could support 500 to 1000 HSCT aircraft, creating a multi-billion dollar sales opportunity for its producers. Such an aircraft will be essential for capturing the valuable long-haul Pacific Rim market. Market studies indicate that the successful development of a U.S.-manufactured HSCT could result in $200 billion in sales and 140,000 jobs for U.S. industry. As currently envisioned, an HSCT aircraft should be designed to carry 300 passengers at Mach 2.4 on transoceanic routes Over distances up to 6.000 nautical miles at fares comparable to subsonic transports.

STRATEGY FOR ACHIEVING GOALS

While current technology is insufficient, the studies further indicate that an environmentally compatible and economically competitive HSCT could be possible through aggressive technology development. NASA is concentrating its investments in the early, high-risk stages of development and the aircraft manufacturing industry has indicated that it is willing to make a substantial investment in this program as the technological risk decreases.

NASA's HSR program is providing a public-sector catalyst in addressing this important opportunity with U.S. industry through a two-phase approach. Phase I. which began in FY 1990, is defining HSCT environmental compatibility requirements in the critical areas of atmospheric effects, community noise and sonic boom and is also establishing a technology foundation to meet these requirements. Phase II of the program began in FY 1994, in cooperation with U.S. industry, and is directed at developing and validating designs, design methodologies and manufacturing process technology for subsequent application by industry in future HSCT aircraft programs to ensure environmental compatibility and economic viability.

At NASA Headquarters, the HSR Program Director is responsible for overall program policy, planning, direction, oversight and funding allocation. Also. the Director is responsible for interfacing with industry, government agencies and the public. Personnel and facilities at the NASA Aeronautics Centers (Ames, Dryden Flight, Langley and Lewis Research Centers) are used to conduct research and analysis in support of the program. At Langley, the lead center, the HSR Project Director reports to the headquarters Program Director and is responsible for policy and program implementation, project planning and funding allocation, systems engineering and integration. and direct contractor interface and management.

The team of primary HSR contractors consists of airframe, propulsion system and advanced flight deck companies. These contractors are responsible for: the research, development and validation of specific technologies: the development and assessment of a next-generation High-speed Civil Transport (HSCT) concept and configuration; and the conduct of associated tasks. such as mission analysis and data base development, as well as for the system-level integration of the advanced technologies being developed. The primary propulsion contractors are the team of Pratt & Whitney and General Electric Aircraft Engines, with contract management by Lewis. The primary airframe contractors are the team of Boeing and McDonnell Douglas, with contract management by Langley. The advanced flight deck contractor is Honeywell International, also managed by Langley. Ames provides significant support directly to Langley in advanced flight deck development, computer modeling and simulation and in economic analysis. Dryden provides support for flight related activities including F-16-XL and the Environmental Research Aircraft and Sensor Technology (ERAST) Program. The HSR Project Office at Langley is responsible for integration of all elements of the program.

The HSR program is enhanced by its participation. in coordination and cooperative efforts to exchange information and data, with other NASA organizations and federal agencies: (1) The Atmospheric Effects of Stratospheric Aircraft Panel includes participation by the NASA Office of Mission to Planet Earth, Environmental Protection Agency, Federal Aviation Administration, National Oceanic and Atmospheric Administration, National Science Foundation and Department of Defense. The panel provides guidance and evaluation of research related to the effects of high-speed civil transports on the upper atmosphere; (2) the FAA/NASA Coordinating Committee provides the framework for developing and defining HSCT certification requirements: and (3) Department of Defense provides a cooperative forum for advanced engine technology development via its Integrated High-Performance Turbine Engine Technology (IHPTET) initiative.

MEASURES OF PERFORMANCE

Sign HSR Phase II Flight Deck contract June 1994	Awarded Flight Deck Concepts contract to Honeywell.
Sign HSR Phase II Air Frame contract July 1994	Awarded Airframe Contract to Boeing/McDonnell Douglas team.
Sign HSR Phase II Propulsion contract September 1994	Awarded Propulsion Contract to Pratt & Whitney/General Electric team.
Verify Noise Reduction (Phase I Milestone) August 1995	Through an analytical combination of noise reduction concept test results, verify capability to achieve Federal Aviation Regulation (FAR) 36 Stage 111 noise rules (environment goal).
Complete HSR Phase I Assessment of Atmospheric Impact - September 1995	Interim assessment of atmospheric effects of supersonic aircraft fleet to support the beginning of considerations for an HSCT emissions standard by ICAO (environment goal).

Select High Lift Concept (Phase II) September 1995	High-lift concept selection based on weight, low/high Reynold number tests of 6%/2.2% models and systems integration (economic goal).
Select Airframe Subcomponent Materials December 1995	Select materials, processes and structural concepts for development of wing and fuselage subcomponent test articles based on material performance, producability production costs and risks (economic goal).
Select Preliminary Engine Nozzle and Inlet Designs (Phase 11)- December 1995	Selection of preliminary engine cycle, nozzle and inlet designs based on systems analyses, aero-acoustic testing, operating cost and environmental acceptability (environment and economic goals).
Select HSCT Preliminary Concept (Phase II) December 1995	Selection of updated HSCT reference configuration for further testing, analysis, and design (environment and economic goals).
Combustor Rig Verification Tests (Phase I) March 1996	Verification of ultra-low NOx formation (goal: 5 grams/kg fuel burned) in engine combustor sector tests (environment goal).
SLFC Flight Test Complete (Phase II) March 1996	SLFC flight experiment on F-16XL-2 completed, critical laminar flow data acquired over a Mach number range and altitudes for CFD code validation and SLFC configuration design code development (economic goal).

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Phase I

Phase I of the HSR program has been extremely successful. Progress has continued in assessing the potential atmospheric impact of HSCT aircraft. The National Academy of Sciences (NAS) conducted a review of the Interim Assessment of Atmospheric Effects of Stratospheric Aircraft released by NASA and commended NASA for performing good work which has enhanced the understanding of atmospheric chemistry. The NAS also recommended that further research be undertaken to allow fully informed decisions concerning HSCT environmental compatibility. a milestone now planned for FY 1998. NASA's ER-2 high altitude science aircraft completed a series of atmospheric observations for the Stratospheric Photochemistry, Aerosols and Dynamics Expedition (SPADE). These in *situ* measurements tested concepts that underlie the stratospheric models used for assessment of HSCT aircraft effects on the stratosphere. Revisions to atmospheric simulation models are being made which will accurately incorporate the measurement data. In recognition of the advancements made in the assessment, industry participants in the HSR program have recommended that the Committee on Aviation Environmental Protection of the International Civil Aviation Organization (ICAO) begin consideration of appropriate HSCT emissions standards at the Committee's next meeting in December 1995. As the year ended, atmospheric observations were being conducted in collaboration with the NASA Office of Mission to Planet Earth's ongoing field evaluation of ozone depletion in the Antarctic winter.

atmospheric observations were being conducted in collaboration with the NASA Office of Mission to Planet Earth's ongoing field evaluation of ozone depletion in the Antarctic winter.

In related engine technology. development of the low oxides of nitrogen (NOx) combustor technology for HSCT engines continued with successful tests of experimental fuel combustion chamber sectors. Initial results achieved or exceeded the goal of generating no more than 5 grams of NOx per kilogram of fuel burned at supersonic cruise operating conditions. The results show that the ultra-low levels previously obtained under highly-controlled laboratory conditions (flametube tests) can transition to practical combustor hardware. Noise reduction, atmospheric effects. airline direct operating costs, and overall technical risk were the key factors in the selection of the two best engine cycles from a pool of six candidates considered. The 'mixed flow turbofan' and 'FLADE' (fan-on-blade) both show significant benefits in reducing engine takeoff noise, while also maintaining good performance at supersonic speeds. Both will continue to be studied for approximately two years before selecting one for the focus of large-scale testing of the critical component technologies in the latter part of this decade.

Phase 11

The HSR program Phase 11 activities accelerated in FY 1994 with the awarding of major contracts which will take the program through to completion in FY 2001. The Airframe contract was awarded to the Boeing/McDonnell Douglas team, the Critical Propulsion Components contract was awarded to the General Electric/Pratt & Whitney team and the Advanced Flight Deck contract was awarded to Honeywell International. During the program life-cycle, the tasks and products are integrated and focused at four key milestones: Preliminary Concept: Preliminary Configuration: Firm Configuration: and Product Launch Commit. with the goal of having increased technology readiness at each of the milestones.

Achievements in advanced technology concepts for development, fabrication and testing of lightweight, high-strength and high-temperature airframe and engine materials continued. An array of airframe composite metal panels and organic matrix composite panels have been fabricated and are being subjected to structural strength tests while a process capable of fabricating up to 10 feet per minute of fiber/resin composite material suitable for high temperature use has been demonstrated. Laboratory tests of Ceramic Matrix Composite tiles used as acoustic liners for noise suppression in the engine exhaust nozzles have demonstrated that the candidate development materials meet the liner strength requirements under static load conditions.

Synthetic vision offers significant payoff in the operational flexibility necessary for an economically successful HSCT to takeoff and land in all weather conditions. A variety of sensor data, including millimeter wave and infrared, have been combined and synthesized onto a single display using advanced software algorithms to provide visibility for pilots in any type of weather.

A future decision by industry to develop a HSCT would require that the aircraft meet stringent certification standards. The advanced technologies that would be incorporated into a HSCT pose new challenges for the current process and requirements of aircraft certification. During FY 1994, NASA began to work with the Federal Aviation Administration on the potential air worthiness standards that would be required to develop the certification basis for a supersonic civilian transport. A Memorandum of Agreement has been prepared identifying responsibilities for developing new certification processes and standards for

supersonic transports and, in addition, a team comprised of members of each agency released a Long-Range Plan for Certification of High-speed Civil Transports.

U.S. aircraft industry and the Russian aircraft firm Tupolev Design Bureau signed a contract in August 1994 to use the Russian Tu-144 supersonic civil transport as a flying testbed for conducting flight research to develop enabling technologies as part of the NASA HSR Program. Tupolev will modify its Tu-144 aircraft and will conduct up to 35 test flights which meet the research needs determined by the HSR Program. The flights will provide aerodynamic, flight environment, structures and handling qualities data on a supersonic passenger aircraft. Ground propulsion tests will also be conducted. The decision to use the Tu-144 was based on a study conducted by a team of engineers from the United States and Russia which concluded that the aircraft would be an effective and economical flying testbed for enabling technology development because of its size. performance characteristics and availability. The Tu-144 supersonic research will establish direct working relationships between aircraft manufacturers in the United States and Russia and also enhance the relationship between United States and Russian aeronautical agencies. Aircraft modifications and mission planning are currently underway with completion of the flight tests planned for November 1996.

In FY 1995. both Phase I & 11 activities will continue. Initial requirements for the Advanced Flight Deck systems will be defined which will encompass the total operational mission profile. The Advanced Flight Deck systems requirements include those concerning external visibility, flight path management, decision aids and flight deck design and integration. Requirements will be defined to meet the HSR program goals of eliminating the "drooped nose" to reduce weight and to have all airport/all weather takeoff and landing capability. The analysis and conceptual design of wing and fuselage structures, including establishment of design criteria and loads, will be completed, as well as the assessment and evaluation of the performance, handling qualities and stability of the HSCT reference configuration. Finally. the assessment will be completed of the effects of a supersonic aircraft fleet on stratospheric ozone and atmospheric contaminants. The analysis will be based on flight tests conducted with research aircraft, satellite data, and preliminary HSR engine component laboratory tests. Based on combustor tests conducted to this point and projected HSCT fleet size, it is predicted that an operational HSCT fleet would have almost no effect on stratospheric ozone (significantly less than 1%).

In FY 1996. the HSR Program plans to complete the selection of an aerodynamic high-lift concept to improve takeoff and landing performance based on wind-tunnel tests. weight analysis. and system integration studies. A selection will be made of metallic and ceramic composite materials to be used in the engine combustor in upcoming laboratory sector tests. Also, a selection will be made of materials, processes and structural concepts for the development of wing and fuselage subcomponent test articles based on material performance, producability, production costs and risks. Preliminary airframe concept selection will be based upon projected capability to achieve Phase II program goals and impact on sonic boom, performance and weight. Selection will be made of preliminary engine cycle, nozzle and inlet designs based on systems analyses, aero-acoustic testing, operating cost and environmental acceptability. The preliminary engine design selection will be based upon projected capability to achieve Phase II program goals of NOx emissions of 5 gm/kg fuel burned and Federal Aviation Regulation (FAR) 36 Stage 111 noise requirements. Each of the requirements definitions, assessments and preliminary design selections will be integrated and a selection made of the Preliminary HSCT Concept. The selected concept will become the updated HSCT reference configuration for further testing. analysis and design. Laboratory testing of engine combustor sectors will continue with the goal of verifying NOx emissions of 5 gms/kg of fuel burned. Flight tests of the supersonic laminar flow control experiment mounted on a modified F-16XL are planned

to be conducted and completed. Data acquired over a range of mach numbers and altitudes will be used to validate Computational Fluid Dynamics (CFD) code of Supersonic Laminar Flow Control (SLFC) configurations.

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Advanced subsonic technology	89,300	125,800	188.400

PROGRAM GOALS

The goal of NASA's Advanced Subsonic Technology (AST) program is to develop, in cooperation with the Federal Aviation Administration (FAA) and the United States aeronautics industry, high payoff technologies to enable a safe, highly productive global air transportation system that includes a new generation of environmentally compatible, economical U.S. subsonic aircraft that are superior to foreign products. To improve the technological competitiveness of the U.S.. the objective of the AST program is to accelerate subsonic technology development in several key areas in which the focus is on the economic value of the technologies to the airframe and engine manufacturers. airlines and FAA.

With competition from foreign competitors greatly increasing, technology is critically needed to help preserve the U.S. aeronautics industry market share, jobs, and balance of trade. Exports in large commercial transports make a significant contribution to the U.S. balance of trade. However, according to industry estimates, the U.S. world-wide market share has slipped from a high of 91% during the 1960's to about 67% today. Increasing congestion in the aviation system and growing concerns about the environmental compatibility of aircraft may limit the projected growth. According to an airline representative, delays in the Air Traffic Control System cost U.S. operators approximately $3.5 billion per year in excess fuel bum and additional operational costs. More stringent noise curfews and engine emissions standards are expected before the end of this century.

STRATEGY FOR ACHIEVING GOALS

The program was initially planned with the full involvement of both industry and the FAA. Close coordination exists between NASA and the FAA for the entire program but particularly in those areas where there is a strong agency synergy: noise. terminal area productivity. short-haul aircraft, environmental, and fly-by-light/power-by wire (FBL/PBW). A management review team. comprised of industry and governmental representatives provided strategic oversight during the developmental stage. and now reviews annual progress to insure that the program continues to meet those needs. The ten critical elements were selected on the basis of industry technology requirements to provide a focused and balanced foundation for U.S. leadership in aircraft manufacture. aviation system efficiency and safety, and protection of the environment. In FY 1996, the AST program will be strengthened by redirection within the ongoing NASA aeronautics program to initiate studies in two areas vital to the future health of the U.S. aviation industry and aviation infrastructure: advanced air traffic technology and affordable design and manufacturing.

Fly-By-Light/Power-By-Wire: The total benefits of full-authority digital computer control have not yet been fully realized for U.S. civil transport aircraft. The goal of the FBL/PBW element is to develop the technology for lightweight, highly reliable, electromagnetically immune control and power management systems for advanced subsonic civil transport aircraft. The FBL/PBW will develop and validate technology for the confident application and certification at reduced cost. The intrinsic electromagnetic

interference immunity of optical technology can significantly enhance acceptability of full authority digital control. The use of power-by-wire results in significant weight savings, simplifies maintenance through elimination of centralized hydraulics, provides for more efficient engine operation, and eliminates the complexity of current generation secondary power systems.

Aging Aircraft: The industry standard practice of inspecting the civil transport airframes visually for damage is labor intensive and highly subjective. The goal of this element is to develop advanced technology that may be used by the U.S. airline operators and aircraft manufacturers to economically extend the life of high time airplanes in the commercial jet transport fleet. The approach is to develop the prediction methodology necessary to calculate the residual strength in airframes and the advanced nondestructive evaluation technology to reliably and economically detect disbonds, fatigue cracks, and corrosion to provide the industry with the tools to economically address the aging aircraft structural safety concerns. The program is strategically linked with complementary programs in the FAA.

Noise Reduction: Aircraft noise is an issue, both nationally and internationally, prompting airports to operate with strict noise budgets and curfews that restrict airline operations. International treaty organizations are actively considering more stringent noise standards which will impact the growth. This element. in cooperation with U.S. industry and the FAA, targets technologies to reduce the aircraft noise levels by 10 decibels (dB) relative to the state-of-the-art by the year 2000 for future subsonic transports. The approach is designed to develop noise reduction technology for source noise reduction, nacelle aeroacoustics. engine/airframe integration. interior noise, and flight procedures to reduce airport community noise, while maintaining high efficiency. The objectives will be achieved via systematic development and validation of noise reduction technology. The timing of the technology development is consistent with the anticipated timing of recommendations for increased stringency.

Terminal Area Productivity: The U.S. aviation industry is investing $6 billion over 20 years to increase airport capacity. However, a gap exists between the industry's desired capacity and the ability of the National Airspace System to handle the increased air traffic. Additionally, current FAA standards require reduced terminal operations during instrument-weather conditions, causing delays and reducing airport productivity and increasing the cost of operating aircraft. The objective is to safely achieve clear-weather capacity in instrument-weather conditions by eliminating inefficiencies associated with runway operations conducted under instrument flight rules. In cooperation with the FAA, NASA's approach is to develop and demonstrate airborne and ground technology and procedures to reduce spacing requirements while maintaining safety, enhance terminal air traffic management, improve low-visibility landing and surface operations, and integrate aircraft and air traffic systems.

Intemted Wine Design: Current approaches to the aerodynamic design of commercial transports rely on methods that develop the design of various wing components independently. which results in an aerodynamic design cycle that is both long and expensive. New design methodology is being developed that treats the wing aerodynamic technologies and components in an integrated manner. To accomplish this, research is conducted in test/measurement techniques and the aerodynamic disciplines of high lift, propulsion/airframe integration, wing design, and laminar flow control. New concepts, design methodologies. model fabrication and test techniques are being developed to provide industry an integrated capability to achieve increased aircraft performance at lower cost. In addition, the new methodologies will be integrated into a design and testing process that reduces the aerodynamic design cycle time by 25%.

Propulsion: In cooperation with the U.S. industry, NASA is developing propulsion technology with the objectives of increasing the competitiveness and market share of the U.S. propulsion industry and reducing the environmental impact of future commercial engines through reduced combustor emissions. The goals of this element are to improve the fuel efficiency of future commercial engines by at least 8%. and reduce nitrogen oxide emissions by at least 70% over current combustor technology. Research and development focuses on combustors, high pressure compressors, high pressure turbines, and high temperature disk and blade materials. Analytical models and computational tools are being developed and validated in engine testing. The products of this element will be incorporated into both future engine designs and derivatives or enhancements of engines currently in service.

Short Haul (General Aviation/Commuter): General aviation in the U.S. represents approximately 45% of the 9 billion air miles flown by all of civil aviation. However, annual U.S. production of general aviation aircraft has fallen to approximately 5% of its 1978 level. In cooperation with U.S. industry through a 50/50 cost-share venture, NASA seeks to revitalize this industry through the development of emerging technologies to improve the affordability, safety, utility and environmental acceptability of U.S. produced general aviation and commuter aircraft. Key enabling technologies include satellite navigation, flat-panel displays, small computers, expert systems, digital data link communications, low-cost manufacturing, and icing protection. By reducing the cost to manufacture aircraft and time required to obtain and maintain safe, all-weather flying skills, expanded use of general aviation is expected to fuel expansion of the national economy by bringing the "off-airways" communities into the mainstream of U.S. commerce.

Civil Tiltrotor: While the tiltrotor aircraft has been shown to be a viable military aircraft (e.g., V-22 Osprey), insufficient research has been undertaken on technologies critical to civil applications such as noise, terminal area operations, safety. passenger acceptance, weight reduction, and reliability. The Civil Tiltrotor element emphasizes development of technology for civil tiltrotor configurations. including noise reduction. cockpit technology for safe, efficient terminal area operations, and contingency power. To achieve acceptable levels of external noise in the terminal area, proprotor noise must be reduced by 6 to 7 dBA (decibel weighted sound spectrum). Complex flight profiles involving steep approach angles up to 15 degrees will be developed to provide an additional 6 dBA reduction. To enable these approaches to be safely flown under all weather conditions, integrated and automated control laws and displays will be developed. The capability to recover from an engine failure requires the development of contingency power options that can provide single engine hover capability without excessive engine weight.

Technolorn Integration: To fully understand the relative payoff of emerging technologies, a systems analysis capability is essential in the development of a credible assessment of the impact of NASA aeronautics technologies on the U.S. industry. As this capability evolves, it supports the Office of Aeronautics and NASA Research Centers in planning and managing the aeronautics program. Understanding the implication of NASA's technology investment on the aviation system minimizes the time intervals from idea generation to implementation. to industry development. and most importantly, to technology transfer.

Environmental Assessment: The objective is to develop a scientific basis for assessment of the atmospheric impact of subsonic commercial aircraft. The goals are to (1) determine the current and future impact of aviation on the atmosphere: and (2) provide assessment reports of future international ozone and climate to serve as the basis for possible cruise emissions standards to be recommended by the International Civil Aviation Organization. Overall program direction and selection of investigators will be

guided by an advisory panel comprised of respected members of the scientific and aviation communities. Early efforts are collecting information on what is known about the issues. Future research will be directed at specific problems to reduce uncertainty in applied scientific knowledge. Elements of atmospheric research (e.g. modeling, laboratory studies, and atmospheric observations) are being complemented by studies unique to the aviation problem (engine exhaust characterization, near field interactions, and operational scenarios).

Composites: The aircraft industry's resistance to using composites is one of economics. While the current demonstrated level of composites technology can promise improved aircraft performance and lower operating costs through reduced structural weight, it does so with increased manufacturing costs, currently twice the cost of aluminum. The goals of the composites element are to reduce the weight of civil transports by 30-50% and their cost by 20-25% compared to today's metallic transports. This translates into a potential 16% direct operating cost-savings to the airlines and increases the competitiveness of the U.S. built transports. In cooperation with industry and the FAA. research is performed to validate the technology for the application of new composites manufacturing techniques, such as through-the-thickness stitching and resin transfer molding, textile preforms and advanced fiber placement, on transport wings.

Advanced Air Traffic Technolom: An efficient and effective air traffic management system is vital to the U.S. transportation infrastructure. An U.S. airlines representative estimates that limitations result in an estimated $3.5 billion annual cost and thousands of hours of delays. In close cooperation with the FAA, the objectives of this element are to develop technologies to enable a revolutionized U.S. air traffic capability and to develop innovative concepts for countries with immature systems. The benefits are reduced costs and a larger aviation market both nationally and in countries where air traffic efficiency is limited. NASA can play a pivotal role by leveraging its expertise in aircraft guidance and air traffic controls technology to develop and validate high risk elements of new air traffic architecture. To assure national coordination, a blue ribbon steering committee consisting of senior government and private sector participants will guide these activities.

Affordable Design and Manufacturing: In response to broad-based industry inputs, NASA also plans to study, in close collaboration with industry. generic "building block" technologies for affordable aircraft and engine design and manufacturing processes. Target areas for study include physics-based process modeling, multidisciplinary synthesis and optimization tools, product and process simulation and visualization, and knowledge-based systems for greater concurrency and integration of product and process environments.

MEASURES OF PERFORMANCE

Fly-By-Light/Power-By-Wire: Fiber Optic System Design - June 1995	Complete fly-by-light flight control system design for advanced civil transports providing the basis for subsystems to be flight tested on transport systems research vehicle.

Aging Aircraft: Verified methodology to predict the residual strength of airframe structures June 1996	Deliver to industry verified (under combined loads) structural integrity analysis codes (FRANC3D/STAGS) able to predict reduction in residual strength of a fuselage with widespread fuselage damage and accidental discrete source damage.
Noise Reduction: Concepts validated for 3 decibel jet and fan noise reduction relative to 1992 technology September 1996	Experimental verification through high fidelity, scale model, 1.5-6 bypass ratio engine simulators concepts (e.g. optimized fan/stator geometries, improved nacelle duct treatment).
Terminal Area Productivity: Develop two-dimensional unsteady model of aircraft laminar wake vortex systems - June 1995	Validate atmospheric model that reproduces the transport and decay of wake vortices near the ground through flight evaluations conducted during field deployments at airports.
Intemted Wing Design: Swept wing suction panel design criteria established - June 1996	Establish hole size. spacing and orientation for optimized suction requirements for laminar flow aircraft.
Propulsion: 60 atmosphere Combustion Test Rig completed - March 1996	Operate national facility for testing large engine sector combustors and full annular combustors for regional engines.
Short Haul (General Aviation): Execute the Joint Sponsored Research Agreement (JSRA) December 1994	Establish and implement cost-sharing alliance with industry, non-profit organizations and government agencies based on the JSRA mechanism for commercialization focus.
Short Haul (Civil Tiltrotor): Flight acoustic database complete - December 1995	Acquire sufficient full-scale tiltrotor aircraft (V-22 and XV-15) noise data for validation of noise prediction codes and for development of low noise operations.
Environmental Assessment: Atmospheric observations from DC-8 Flying Laboratory September 1996	Gather data from first in situ observations dedicated to subsonic scientific assessment to address effects of contrails on earth's radiation. potential effect of aircraft exhaust on ambient cirrus, and the effect of aircraft soot or sulfate.
Composites: Wing configuration requirements document - December 1996	Select aircraft configuration; select targets for loads. damage scenarios. weight and cost.

ACCOMPLISHMENTS AND PLANS

Fly-By-Light/Power-By-Wire: In FY 1994. the experimental laboratory for assessing the effects of high intensity radiated fields on electronic systems and avionics was completed and used to validate the behavior of electromagnetic (EM) flight test instrumentation. Critical optical and power components, such as electrical actuators and fiber-optic sensors and cables, were exposed to a simulated flight environment. In FY 1995. the EM instrumentation was ground tested on the transport systems research vehicle (TSRV) and will be flight tested later in 1995. Several types of fiber-optic components and electrical actuators will be flight tested and validated on the systems research aircraft. In FY 1996, the EM environment modeling code will be validated using results from TSRV flight tests. A preliminary flight test assessment of the integration of basic FBL/PBW components will be completed and provided to industry. The results will be incorporated in the commercial transport verification and validation plan.

Aging Aircraft: During FY 1994, efforts focused on the development of an analytical methodology to predict the residual strength of the fuselage. In cooperation with several U.S. airlines and the U.S. Air Force, progress was also made in developing and demonstrating advanced, large-area non-destructive evaluation (NDE) methods to reduce cost while maintaining the reliability of the inspection. During FY 1995, a portable, hand-held, battery operated electromagnetic probe for detecting small cracks in thin sheet aluminum. showing great promise to be low-cost and very reliable, is being evaluated by industry to identify further refinement requirements. Damage tolerance tests will be conducted with various simulated fatigue and accidental damage to fully exercise and validate the predictive capability of the analytical methodology. In FY 1996, the analytical tools to predict the residual strength of a fuselage with fatigue crack and accidental damage will be provided to industry. Work will continue in the development of signal processing techniques and field demonstrations of prototype NDE systems.

Noise Reduction: In FY 1994. a key research tool, the first integrated fan noise source and propagation prediction code was developed and provided to industry. Methods for reducing noise levels in aircraft interiors were validated in laboratory tests to help refine their application for future flight demonstrations. Activities in FY 1995 include jet noise research on enhanced mixing nozzles applicable to current engine technology, testing of active and adaptive noise control techniques that ultimately will be used to reduce noise radiated from engines, and the use of computational aeroacoustics in the design of quieter landing gear and other aircraft components. Acoustic imaging will locate the optimal locations of active noise control actuators to reduce interior noise. In FY 1996, experiments will be conducted on concepts to improve nacelle duct noise treatment effectiveness. Testing will be completed on concepts for a jet noise and fan noise reduction. Other activities include the selection of an active noise control concept for engine demonstration, the completion of a engine noise database, the release of the community noise impact model, and a demonstration of an active structural acoustic control on a business aircraft.

Terminal Area Productivity: In FY 1994, in order to allow more adaptable spacing, reduced separation requirements were investigated by evaluating wake vortex issues and community noise constraints. and the potential for integrating enhanced aircraft flight management and the air traffic management systems was examined. The replacement for the transport systems research vehicle (TSRV) was acquired. In FY 1995. installation of an existing simulator and associated computer systems on the TSRV began in preparation for future flight tests. In the area of improving the capacity in the airport. two-dimensional laminar wake vortex models will be developed. A study to project potential landing, roll-out. take-off and taxi bottlenecks and estimates of the cost versus benefit of new concepts for low-visibility operations will be completed. In FY 1996, the research flight system

installation on the replacement TSRV will be completed and flight testing will begin. Adaptive wake vortex separation criteria will be validated to provide a tool for airport-airspace planners to make decisions on spacing between aircraft.

Integrated Wing Design: In FY 1994, a large laminar flow swept wing model was designed and fabricated. The state-of-the-artwas established and deficiencies identified for current methods for designing wings and high-lift devices. In FY 1995, testing of the laminar flow model will be completed in the 8-foot transonic pressure tunnel. Improvements were initiated in wing design methods based on the identified deficiencies. A cost/benefit analysis of the impact of wing design concepts and methods on aerodynamic design cycle time, aircraft performance and cost will be completed. In FY 1996, manufacturing constraints will be established for future low-drag, highly efficient laminar transport aircraft. The pressure sensitive paint system will be packaged into a portable system for demonstration. New concepts for improving the design process will be tested. Comparisons of new concepts with conventional test techniques will demonstrate shortened wind tunnel test times and reduced design cycles for aircraft development.

Propulsion: In FY 1994. engine system studies to define optimum engine cycles and associated enabling technology needs for the large engine manufacturers were completed. Similar studies to define technology needs of regional aircraft engines were initiated. Advanced combustor concepts were evaluated. In FY 1995. experimental evaluation of advanced low emissions combustors is continuing. Assembly of the unique high pressure/temperature combustion research rig will be completed. Efforts have been initiated to improve turbine cooling technology, and improve turbomachinery aerodynamics in both high pressure compressors and turbines. In FY 1996, the 60 atmosphere combustion test rig will be checked-out and ready to provide valuable assessment of low emission combustors for advanced engines. The first test is scheduled to evaluate low emissions lean direct injector concepts for future aircraft engines. An evaluation of an integrated propulsion/airframe system will be completed.

Short Haul (General Aviation/Commuter): In FY 1994. an economic analysis of the status of the general aviation (GA) industry and the areas where technology can contribute to its revitalization was conducted. During FY 1995, the Joint Sponsored Research Agreement for GA/Commuter Alliance between NASA, the FAA, and several U.S. small airplane manufacturers and suppliers was initiated. A ground-based cockpit simulator used to evaluate future communications, weather and situational awareness continues to be assembled with prototype hardware. Integration of simplified engine control displays into the airborne simulator cockpit display system will be completed. In FY 1996. the computer operating architecture for future GA control and displays will be identified. Displays and communication hardware will be integrated in the testbed. Also, the NDE processes will be validated for use in certifying manufacturing of small composite components. Icing protection system design guidelines for safe operation of GA aircraft will be developed.

Short Haul (Civil Tiltrotor): In FY 1994. innovative noise reduction concepts for the civil tiltrotor were evaluated. Three and four-bladed rotor wind tunnel tests provided acoustic and aerodynamic data to establish baselines and trends for noise and aerodynamic performance. In FY 1995, viable civil tiltrotor rotor noise reduction concepts are being identified for further research. Innovative noise reduction concepts will be refined and the active source noise control will be evaluated for the tiltrotor configuration. Displays and pilot-to-cockpit interfaces for low noise approaches of the civil tiltrotor will be identified. During

FY 1996, scale model acoustic testing will be completed as will the flight acoustic database. An investigation of low noise procedures will begin in the vertical motion simulator and contingency engine power concepts will be selected for preliminary design.

- Technolorn Integration: In FY 1994. the development plan for a systems analysis capability for the aviation system was completed. In addition, in-house capabilities for modeling and analyzing aircraft. engines, air traffic control, and environment were improved. During FY 1995. plans for implementing integration, operation and maintenance procedures will be developed and a quick-response database of economic parameters of the aviation system will be completed. In FY 1996, the incremental development of the aviation system analysis capability will continue with the development of an executive architecture and the economic analysis module.

Environmental Assessment: During FY 1994, studies were initiated in an attempt to identify possible indicators from existing atmospheric observations data and to identify where additional measurements are needed. Plans for sensitivity studies utilizing computer simulations of atmospheric processes were completed. In 1995, computational capability will be developed for analysis of the chemical processing which occurs in the mixing of engine exhaust with the background atmosphere. Exhaust trace chemistry for operational engines will be measured. In FY 1996, the first program level assessment report on the atmospheric impact of subsonic aviation will be completed, leading to participation by principal investigators in preparation of 1997 United Nations Environment Program/World Meteorological Organization (UNEP/WMO) ozone assessment report. Also. the first in situ atmospheric observations dedicated to subsonic aviation assessment will be performed aboard the DC-8 flying laboratory.

Composites: In FY 1995. the composites element will be initiated to develop and validate at full-scale the composite structures technology, including validation of design concepts, structural materials. and manufacturing methods, required for manufacturing composite wings while saving weight and cost compared to conventional metal commercial transports. Contracts will be awarded for the design, fabrication and test of a full-scale wing for the application of composites on next generation civil transports. In FY 1996, based on the technology developed in the recently completed Phase B of NASA's advanced composites technology program, this element will accelerate the effort to validate the application of composites to commercial transport wings by completing the baseline aircraft and requirements document for composite airframes, candidate materials identification, along with cost and weight trade and sensitivity studies.

Advanced Air Traffic Technology: In FY 1995, to ensure national coordination, a blue ribbon steering committee consisting of senior government and private sector participants will be established to guide activities. In FY 1996, the effort will start with system concept studies addressing both airborne and ground elements of candidate system architectures through integration of aircraft guidance and air traffic controls technology. Study results will provide a sound basis for future concepts and technology selection and for defining the next generation air traffic system requirements. Plans for subsequent program phases include high-leverage technology development and validation, system simulation modeling, and an evaluation within a real environment using actual aircraft and air traffic ground systems and procedures.

Affordable Design and Manufacturing: In FY 1996. in close collaboration with industry, studies will identify generic "building block" technologies for affordable aircraft and engine design and manufacturing processes and methods for improving test facility capabilities through advanced test technologies and real-time integration of the design and test environment. Plans for subsequent phases would develop these tools and methodologies to dramatically reduce design and manufacturing cycle time and cost, while ensuring high quality. These studies will also include methods for improving test facility capabilities through advanced test technologies and the real-time integration of the design and test environment through aggressive utilization of information technology.

BASIS OF FY 1996 REQUIREMENTS

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Transatmospheric research and technology	20.000	--	--

PROGRAM GOALS

The Transatmospheric Research and Technology program was the NASA portion of the joint NASA/DoD National Aero-Space Plane (NASP)program. The goal of NASP was to develop the technology for reusable, Single-Stage-To-Orbit(SSTO) vehicles with airbreathing primary propulsion, as well as horizontal takeoff and landing. Operational aerospace planes with such capabilities offer the flexibility, efficiency, safety and economies of operations to revolutionize U.S. access-to-space.

STRATEGY FOR ACHIEVING GOALS

The NASP program was jointly funded and managed by NASA and DoD. A team of five prime contractors executed the program in concert with some Government laboratories and research centers. NASP sought to advance a wide-ranging set of technologies -- including aerothermodynamics, propulsion, high-temperature materials and structures. hypersonic guidance and control, and advanced computational fluid dynamics. The program had specific criteria by which to judge when (or if) to move from the major technology-development phase into building and then flying the X-30, an SSTO flight-research vehicle. Flight was determined to be necessary to reach beyond the limitations of ground tests and computational analytics; flying the X-30 would also demonstrate the NASP technologies as integrated into an entire vehicle.

MEASURES OF PERFORMANCE

Complete Mach 6.8 and 12 - 17 scramjet November 1994	Defined and documented improvements to scramjet performance and operability tests through medium/large-scale wind tunnel tests.
Complete structural technology tasks September 1994	Defined state-of the-science through: final tests of cryogenic fuel tank and TMMC "Sigma", "BB-Beta", "Side-Shear" and H2/He/N2 actively-cooled panel. fabrication of "Full-Scale Fuselage" panel assembly.
Complete and document all NASP Government Work Package tasks December 1994	Complete testing, analysis and reporting on: Mach 10 airframe/propulsion integration: high-temperature metallic/ceramic/composites characteristics, scramjet wind-tunnel diagnostics systems, high-temperature structural sensors (strain gages, fiber-optic systems), etc.

ACCOMPLISHMENTS AND PLANS

The U.S. hypersonic technology base at the end of calendar-year 1994 consisted largely of results from the **NASP** program. The **NASP** team documented not only the **X-30** design/technology-integration work but also an expansive array of **NASP** technology work. The major tasks in structures and materials included: fabrication of a unique 10-by-12-foot panel of titanium metal-matrix composites (TMMC); thermomechanical tests of several other large TMMC panels and one of carbon-carbon: high-heat-flux tests of actively-cooled panel assemblies: and load tests of a unique, new 600-gallon cryogenic-fuel tank. **NASA** completed Mach 10 wind-tunnel tests of a complex, propulsion-integration model for **NASP.** Mid-speed (Mach 6.8) scramjet wind-tunnel testing produced important performance/operability data from the **NASP** 1/3-scale Concept Demonstrator Engine (CDE); complementary tunnel tests utilized smaller-scale, scramjet models at Mach **4** to 8 conditions. Shock-tunnel tests of large-scale, scramjet-combustor models at Mach 10 to 17 provided vital new information through advanced instrumentation -- including laser-based systems and a metric strip. Analytic activities defined new boundary-layer instability modes and provided a series of major computational modules for aerothermodynamic predictions. Technology transfer **also** remained very productive in FY 1994. In 1994, Congress directed the conclusion of the program while it was in the technology-development phase.

BASIS OF FY 1996 REQUIREMENT

CONSTRUCTION O FACILITIES

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996
National aeronautical facilities	172.000	--	--
Unitary plan 11-foot wind tunnel (ARC)	20,000	--	--
Modifications to composite technology center (LeRC)	27,000	--	--
Modification to NTF for reliability (LaRC)	51,000	--	--
New facility study/design (HQs)	74,000	--	--
Aeronautical facilities revitalization	31,000	22,000	5,400
Rehab of control systems, national full-scale aerodynamics complex (ARC)	2,100	--	--
Upgrade of outdoor aerodynamic research facility (ARC)	3,900	--	--
Modernization of Unitary Plan Wind Tunnel (UPWT) complex (ARC)	25,000	22,000	5,400
To	203.000	22,000	5,400

PROGRAM GOALS

This program continues an effort to upgrade the U.S. aeronautics facilities capability. The U.S. has been increasingly challenged in world aeronautics markets for some time. Since 1984. its share of those markets has dropped with a corresponding loss of numerous jobs. It is important that this trend be reversed. The Administration is encouraging implementation of a national goal to infuse the U.S. industry with the capability to develop a new generation of civil and military aircraft which will outperform the competing products of its international competition at comparable or lower cost.

The facilities program goal is to provide the high priority facilities needed to enable development of the advanced aeronautical technology required to ensure superior performing and cost competitive U.S. aircraft.

STRATEGY FOR ACHIEVING GOALS

In FY 1988, a $300 million Aeronautical Facilities Revitalization program was initiated to revitalize 23 of NASA's major wind tunnels. This program will be completed with the implementation of the final phases of the Unitary Plan Wind Tunnel (UPWT) in FY 1995 and FY 1996. The UPWT is a vital national high-speed tunnel facility consisting of one transonic and two supersonic test sections along with supporting auxiliary equipment. This facility is the most heavily used wind tunnel complex in NASA but its productivity has been limited by the 1950's era control systems and the increasing frequency of equipment breakdowns due to age and heavy use. The planned improvements will improve the productivity data, data quality, and reliability of this facility. Repair or replacement of tunnel components that have reached the end of their useful life is required. Also, the welds in the tunnel shell contain defects typical of 1950's technology and must be repaired and the pressure shell rectified.

In FY 1993. a National Aeronautical Facilities Upgrade program was started. These upgrades and revitalizations. and other upgrades planned in the aeronautics 5-year plan will provide the U.S. with the wind tunnel infrastructure needed to help maintain world leadership in aeronautics. In FY 1994, facility studies and definition of requirements for new or drastically modified set of U.S. wind tunnels have been initiated.

MEASURES OF PERFORMANCE

Complete construction of 40x80 Wind Tunnel Acoustic Enhancement - December 1996	Complete construction on schedule, within budget and meeting all requirements. Complete operational readiness review by March 1997.
Complete construction of UPWT project - November 1997	Complete construction on schedule, within budget and meeting all requirements. Complete operational readiness review by September 1998.
Complete 11-Foot Performance Improvements - November 1997	Complete construction on schedule, within budget and meeting all requirements. Complete operational readiness review by September 1998.
Complete the Composite Technology Center - August 1997	Complete construction on schedule, within budget and meeting all requirements. Complete operational readiness review by October 1997.
Complete NTF Upgrades September 1998	Complete construction on schedule, within budget and meeting all requirements. Complete operational readiness review by March 1999.

ACCOMPLISHMENTS AND PLANS

The National Aeronautical Facilities Upgrade program began in FY 1993. The first upgrade, involving acoustic treatment to the 40x80 foot wind tunnel at Ames Research Center (ARC) was initiated in FY 1993 by an added appropriation to the NASA budget.

Once completed, the upgrades will greatly improve the facilities capability for experimental measurements of noise generated by engines, rotorcrafts and airframe-engine interactions. The National Transonic Facility (NTF) project at the Langley Research Center (LaRC) that was funded in FY 1994 is currently in the design phase. The NTF will be enhanced by having its own drive control and increased nitrogen storage capacity. These productivity enhancements will improve facility reliability and reduce test times. Final design has been initiated on the ARC Unitary Plan 11-foot wind tunnel. In this wind tunnel, the drive motors will be rewound and existing rotor blades will be replaced. These enhancements, along with other productivity improvements. will reduce model preparation and test occupancy times as well as increase overall facility reliability. Final design has also been initiated in the Lewis Research Center (LeRC) Composites Technology Center. Once completed, the Composites Technology Center will provide the means to develop high temperature composite materials enabling the development of aircraft engines that are environmentally acceptable and economically competitive. The modernization of the UPWT modernization project continues in FY 1995 with the final funding increment requested in FY 1996. The work in FY 1995 and FY 1996 will continue on automation, flow quality, piping, pressure vessel and control room work packages. The total cost of the UPWT modernization project is estimated to be $60.4 million.

BASIS OF FY 1996 REQUIREMENT

NATIONAL AERONAUT FACILITIES

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
National aeronautical facilities		400,000	

ACCOMPLISHMENTS AND PLANS

The facility studies initiated in FY 1994 as part of the National Aeronautical Facilities program examining new or modified wind tunnels that are mentioned in the Aeronautical Research and Technology Construction of Facilities narrative will continue in FY 1995. As part of the facility studies program, $74 million was appropriated to conduct initial design studies for possible new wind tunnel facilities. The industry/government team is examining all options, refining cost estimates. and advancing design to the point where government and industry will be able to decide whether to invest funds with confidence that the final product will fulfill all stated criteria and be delivered on time and within budget. A significant cost sharing arrangement with industry is required and an important part of Industry's decision to invest in the National Wind Tunnel Complex (NWTC) will be based on the Government's commitment to substantially fund the program upfront. The Administration is requesting that the availability of the $400 million appropriated in FY 1995 for the NWTC be extended until FY 1997.

Space Access
and Technology

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE ACCESS AND TECHNOLOGY

SPACE ACCESS AND TECHNOLOGY

OF JRC ES REQUIREMENTS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	page Number
Advanced space transportation	109.100	162.100	193,000	SAT 5-5
Spacecraft and remote sensing	183.300	144,300	177,500	SAT 5-13
Advanced smallsat technology	12,500	61.900	33,900	SAT 5-22
Space processing	19.500	18,300	18,100	SAT 5-25
Flight programs	140,900	49,100	76.000	SAT 5-28
Commercial technology programs	27.800	45,800	40,400	SAT 5-34
Launch vehicles support	37.100	37.000	37,600	SAT 5-37
Industry technology program	19.700	[18,900]	--	
Small business innovation research programs	[110,9001	123.900	129,100	S 5-40
Rehabilitation of rocket engine test facility (LeRC) - COF	12,500	--	--	
To	562,400	642,400	705,600	

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL *YEAR* 1996 ESTIMATES

BUDGET **SUMMARY**

OFFICE OF SPACE ACCESS AND TECHNOLOGY SPACE ACCESS AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

Distribution of Program Amount by Installation

Johnson Space Center	93.900	23.700	32.800
Kennedy Space Center	11.500	15.900	17.200
Marshall Space Flight Center	63.500	145.200	175.500
Stennis Space Center	9,000	14.000	18.000
Ames Research Center	25.300	31.600	33.900
Dryden Flight Research Center	--	300	200
Langley Research Center	39.200	55.400	79.400
Lewis Research Center	73.200	59.000	87.400
Goddard Space Flight Center	39.300	55.700	61.900
Jet Propulsion Center	61.400	69.000	80.500
Headquarters	146.100	172.600	118.800
Total	562.400	642.400	705.600

OFFICE OF SPACE ACCESS AND TECHNOLOGY

PROGRAM GOALS

The goal of the Space Access and Technology program is to pursue, in partnership with industry and government, new and innovative technologies which will meet the challenges and lower the costs of future space missions. The Space Access and Technology program stimulates the development of advanced space technologies which improves the international competitiveness of U.S. aerospace and non-aerospace industries. The ability of the United States to compete in the global market mandates that the U.S. develop new and innovative technologies that will dramatically lower the cost to develop, build and launch new spacecraft.

STRATEGY FOR ACHIEVING GOALS

The Space Access and Technology program has four major purposes. Consistent with the National Space Transportation Policy. the first purpose is to develop technology to revitalize access to space. NASA will develop technology as a member of the national team for the next generation space transportation system with a target of reducing launch vehicle development and operations costs dramatically after the year 2000. NASA will also participate with the Department of Defense (DoD) in developing technology to improve the competitive position of existing launch vehicles. The program to develop the next generation of launch vehicles will include systems engineering and concept analysis, ground-based technology development. and a series of flight demonstrators (the DC-XA, the X-34 Small Booster and the X-33 Large-Scale Advanced Technology Demonstrator). Each part of this closely integrated program contributes to the process of validating key component technologies. proving that they can be integrated into a functional vehicle, and demonstrating that they can be operated as required to make low-cost access to space a reality.

The second purpose is to provide new and innovative space technologies to meet the challenges and lower the cost of future space missions. Meeting these challenges will require improved instrument detector technologies to optimize sensitivity and resolution across the electromagnetic spectrum. This work involves increasing detector array sizes for all science observations and developing submillimeter heterodyne components for Earth science and astrophysics. Lowering space mission costs requires demonstration of a new paradigm in spacecraft design-to-launch by reducing spacecraft cost fifty percent by 1997. reducing operations cost thirty percent by 2000, and demonstrating development-to-flight times of two years.

The third purpose is to nurture and expand commercial space industries by proactively developing, demonstrating and transferring NASA technology to aerospace and non-aerospace applications. Specifically, NASA is working to accomplish the following by 2000: develop communications spacecraft technology as a component of a global information infrastructure capable of exceeding current data rate transfer capabilities; stimulate a threefold market expansion of remote sensing and other Earth applications by coupling spacecraft and data systems capabilities to user needs; and foster five new businesses in biotechnology and materials processing which utilize the unique attributes of space. In addition, NASA intends to make the commercial technology transfer network fully

operational by 1996. The network will give entrepreneurs access to one hundred percent of current, non-sensitive technology activities and opportunities.

The fourth purpose is to provide successful, on-schedule, expendable launch vehicle (ELV) space launch services for all civil U.S. Government missions at the best price and value possible. Funding for ELV launch services required to carry out NASA missions has historically been consolidated in one budget element within the Space Sciences program budget requirement. In NASA's strategic planning effort over the past year, there was general agreement that the budget requests for each NASA program should reflect the program-specific ELV funding requirements. This decision is reflected in the FY 1996 NASA budget. The mission support costs which are not program-specific are included in the Space Access and Technology program budget.

BASIS OF FY 1996 FUNDING REQUIREMENT

ADVANCED SPACE TRANSPORTATION

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Advanced launch technology...	20.000	--	--
Reusable launch vehicle - systems engineering & analysis	3,500	4,600	4,700
Reusable launch vehicle - technology program	28,400	76,900	59,300
Reusable launch vehicle - initial flight demo prog (FDP)	2.300	47,000	60,000
Reusable launch vehicle - FDP post-December 1996 continuation	--	--	35.000
Transportation technology support	54,900	33,600	34,000
To	109.100	162.100	193,000

PROGRAM GOALS

The goal of the Advanced Space Transportation program is to develop new technologies aimed at revolutionizing access to space. These new technologies are targeted at reducing development and operational launch costs dramatically over the next decade, increasing the safety and reliability of both current and next generation launch vehicles, and increasing the reliability of spacecraft propulsion systems while reducing cost and weight.

STRATEGY FOR ACHIEVING GOALS

In accordance with the National Space Transportation Policy released in August 1994, NASA is taking the lead in developing the technology for the next generation reusable space transportation system. The program will include systems engineering and concept analysis, ground-based technology development, and a series of flight demonstrators (the DC-XA. the X-34 Small Booster and the X-33 Large-Scale Advanced Technology Demonstrator).

As directed by National Policy, the X-33 program will face two major decision points, one no later than December 1996 and the other by the end of the decade. The 1996 decision will be whether to proceed with the large-scale flight demonstration, while the choice at the end of the decade will determine if government and industry are going to move ahead with full-scale development of an operational launch system. Both decisions will be based on criteria established in early 1995 and agreed to by NASA, OMB, and OSTP, with the advice of an outside panel of experts. The program's progress toward meeting the criteria will be reviewed annually. A substantial portion of the funding for the program in FY 1996 through FY 2000 has been reserved in a separate budget line within the Space Transportation budget. The release of these funds for obligation will be contingent on Administration

agreement in 1996 that, based on the established criteria, the program is ready to proceed into the large-scale flight demonstration phase.

Each part of this integrated program contributes to the process of validating key component technologies, proving that they can be integrated into a functional vehicle, and demonstrating that they can be operated as required to make low-cost access to space a reality. Technologies in work include lightweight, durable, low-maintenance thermal protection. vehicle health management, reusable cryogenic tank systems and advanced propulsion systems. DoD's DC-X flight demonstration program has successfully flown a rocket-powered vertical takeoff and landing vehicle. NASA intends to retrofit this vehicle with new, lightweight aluminum-lithium and composite cryogenic tanks, a composite intertank structure, modified auxiliary propulsion and power systems and health management sensors. This work, to begin in FY 1995, will give an early indication of the viability of these new technologies. If successful, the technologies, as well as the operational lessons learned, will be applied to the other flight demonstrations. The mature technical information generated by this program will then enable informed government and private sector decisions on whether to proceed with development of an operational next-generation reusable launch system.

NASA is utilizing an innovative management strategy for the Reusable Launch Vehicle program, based on industry-led cooperative agreements between a variety of industry and government participants. Those participants currently include contractors such as McDonnell Douglas Corporation. Huntington Beach. CA; Boeing Corporation, Seattle, WA Martin Marietta Corporation, Bethesda, MD: and Rockwell International Corporation, Downey, CA. The primary government participants are NASA's Langley Research Center (LARC), Ames Research Center (ARC) and Marshall Space Flight Center (MSFC), and DoD's Phillips Laboratory. Each current partner on the RLV program is contributing manpower, facilities and funds to the technology development effort. This cost-sharing will continue under the two new cooperative agreements to be signed for the X-34 and X-33, with industry contribution to the X-34 anticipated to be at least *fifty* percent of the total investment in the small booster program.

The DoD, specifically the U S. Air Force (USAF), will play several key roles in the reusable launch vehicle (RLV) technology program. The cooperative NASA/USAF technology program will provide the technology base for future, related applications of both agencies. The USAF has technologies in reusable cryogenic tanks, thermal protection systems, and advanced LO2/LH2 engine technologies. In addition. the USAF will bring its expertise in aircraft operations, maintenance, and flight testing to the cooperative RLV activities. With these capabilities. the USAF will provide leadership in the RLV flight demonstration program by helping to develop operations concepts. and by performing flight test planning, range facilitation. and operations.

The DoD has also pioneered some of the management principles for low-cost development and operation of experimental rocket powered vehicles, as demonstrated in the DC-X program. One of the principles in reducing program cost is leaner management structure: therefore, as part of the effort to reduce program overhead and increase management efficiency, NASA's MSFC will be the host center for the RLV program, but the small program office located at the center will be directly responsible only to the Program Director and the Associate Administrator for Space Access and Technology at NASA Headquarters. This management structure will reduce program management staff to a maximum of 12 and will eliminate two layers of management.

In addition to the RLV effort, the National Space Transportation Policy calls on NASA to support other agencies and technologies in enhancing all means of access to space. Therefore, the Transportation Technology Support budget element funds a variety of

efforts to reduce the cost and improve the reliability. operability, responsiveness and safety of expendable launch vehicles, solid rocket motors, spacecraft propulsion systems and launch operations. The programs funded within the Transportation Technology Support budget line are Expendable Launch Vehicle Cooperative Tasks, Operations/Software Technologies. Solid Propulsion Integrity Program (SPIP). In-Space Transportation and Engineering Capability Development. Similar to the RLV cooperative efforts, the primary management concept for Transportation Technology Support efforts is to share costs and benefits between government and industry.

NASA's strategic goals for space transportation mandate the reduction of costs for expendable launch vehicles (ELV's) to enable future missions during this time of diminishing budgets. NASA has made significant investments in launch vehicle technologies and experimental facilities. ELV Cooperative Tasks, which are conducted with the industry providing significant cost sharing, are to be completed in FY 1996. However, NASA will continue to support the DoD as lead agency for implementing ELV improvements in areas where NASA's unique facilities and expertise can assist the government and industry.

As part of NASA's continuing effort to reduce the costs of current launch vehicles, the Operations/Software Technology program utilizes a core of technical experts at ARC working with the Shuttle project organizations. The objective is to develop and demonstrate expert system-based technologies which will reduce the cost of vehicle processing, launch and mission operations. NASA efforts for next generation vehicles will also benefit from this effort through early demonstrations of relevant technologies.

The purpose of the Solid Propulsion Integrity Program is to put in place the engineering capability for improving the success rate of US-built solid rocket motors, for mitigating and managing the motors' risk, and for enhancing the economic competitiveness of the solid rocket motor industry. The SPIP strategy is to establish government/industry teams to resolve uncertainties within the industry via science and engineering, and to place science and engineering into the heads and hands of the nation-wide infrastructure of solid rocket motor designers, manufacturers, verifiers. and users. One key measure of the program's success will be the number of SPIP products being used by industry. Although NASA is the lead agency, DoD provides tests, facilities, and expert personnel at minimal costs to SPIP, and industry contributes independent research and development (IR&D) products as well as expert skills and experience. In fact, industry provides approximately 10% - 15% equivalent funding on bondline and nozzle activities, and industry contributions toward the combustion simulator efforts have reduced government funding requirements by approximately 30%. In accordance with the direction received in a December 15, 1994 letter from the Committees on Appropriations, NASA is examining alternative funding sources to allow FY 1995 funding for SPIP to be increased from the current level of $7.6 million to the $12.9 million directed. The agency will inform Congress in a letter asking for a change to the FY 1995 Operating Plan when the source of the additional SPIP funding is decided.

The goals of the In-Space Transportation technology development program are to develop and demonstrate major technology advances in very high performance spacecraft propulsion systems, which will reduce launch costs and increase the life and useful payload capability of commercial, science and military spacecraft. For the near-term, NASA's Lewis Research Center (LeRC) has several ongoing cooperative efforts with spacecraft developers and users, as well as with advanced propulsion system manufacturers. Additional cooperative agreements are being initiated in FY 1995 and 1996. The major focus of this near-term cooperative work is to integrate innovative power and propulsion systems. particularly on small, low-power spacecraft. These new technologies promise reductions in propulsion system size and weight requirements, thereby shrinking the size of the spacecraft

and its launch vehicle, while maintaining or enhancing the life and payload capability of the satellite. For the longer-term. In-Space Transportation funds university-based analytical and experimental assessments of critical technology issues for very advanced propulsion and power concepts to enable a broad class of future exploration missions. In-Space Transportation efforts also include the development of automated rendezvous and capture technologies to enable uncrewed vehicles to service in-space assets or re-supply the Space Station.

Several organizations are involved in the In-Space Transportation technology work. In the area of technology for small satellites and for space storables. LeRC is working with several companies. including Hughes Aircraft and Martin-Marietta. Apogee engine work is being done cooperatively with Atlantic Research Corp. and TRW, with strong DoD/foreign interests. Industry (Teledesic) has an interest in LeRC's pulse plasma rockets for communication satellite constellations. Industry will continue to utilize the LeRC test beds for specific tasks. e.g., evaluations of rocket plumes, thrust accuracy and electromagnetic interference. The solar electric flight systems propulsion project was initially planned with DoD and is expected to have a continuing strong DoD interest.

The Engineering Capability Development element provides for the utilization, maintenance. and productivity upgrades for the premiere national facilities required to accomplish the goals of the Advanced Space Transportation programs. For example, the evaluation and optimization of the aerodynamic and aero-heating characteristics of the next generation launch vehicle configurations will require the availability of national facilities (the NASA Langley Aerothermodynamic Facilities Complex and the NASA Ames Arc Jet Complex). World class computational fluid dynamic analysis capabilities will be required to establish real gas thermochemistry and materials response effects on candidate configurations' aero performance and to design thermal protection systems.

MEASURES OF PERFORMANCE

Release of the Cooperative Agreement Notices for the X-33 and X-34 January 1995	The Cooperative Agreement Notices request proposals by industry for the X-33 Advanced Technology Demonstrator and the X-34 Small Booster Flight Demonstrator.
Industry proposals for the X-33 and X-34 due February 1995	A rapid response by industry, as well as an expedited selection process by NASA, are required if the X-34 is to meet program goals of first flight by late 1997. and if the X-33 program is to be ready for a decision to proceed no later than December 1996, per National Policy.
Application of second generation arcjets for commercial satellite station keeping September 1995	First generation systems were commercially deployed in 1994. Qualification-level tests of second generation arcjets will be conducted with industry participation. The system will be baselined for next generation satellites.

Decision to proceed with the X-33 Advanced Technology Demonstrator September 1996	Detailed criteria for measuring the readiness of the RLV program to proceed with the X-33 ATD will be provided separately as part of this budget submission.
Completion of Cooperative ELV Tasks: - Testing Al-Li cryogenic tank segment to failure - Demonstrating end-to-end electro-mechanical actuator system - Demonstrating advanced diagnostic tools September 1996	These advanced technologies will transition to the industry partners to reduce costs, improve reliability and/or improve payload performance of evolved ELV systems.
Initial Operation of SPIP Solid Rocket Motor Combustion Simulator September 1996	The simulator will be completed on time. The extent of utilization of the facility will also be monitored in the future.
Complete First Flight-Ready Solar Electric Flight System September 1996	System weight, size. and cost targets will be met. A cooperative flight demonstration experiment will be initiated.

ISHMENTS AND PLANS

Reusable Launch Vehicle (RLV)

In July 1994, NASA initiated six cooperative agreements in the structures and thermal protection system area with McDonnell Douglas Corporation and Rockwell International Corporation. Task areas include multiple. small-scale demonstrations of reusable cryogenic tank systems. thermal protection systems, and composite primary structures. NASA also started 11 cooperative agreements in the advanced propulsion area with several industry partners, including Aerojet, Martin Marietta, McDonnell Douglas, Pratt & Whitney, Rocketdyne, and Rockwell. Among the agreements' task areas are composite component development, integrated propulsion systems, tri-propellant main injectors, tri-propellant preburners, oxygen-rich turbine drives, and modular chambers. Preliminary design and some component-level fabrication testing was completed in FY 1994.

In 1995, advanced launch vehicle concept analysis and technology development will continue. In addition, work will begin to upgrade the DC-X vehicle to the DC-XA configuration and new cooperative agreements between NASA, DoD and private industry

are to be signed to start work on the two new flight demonstrators. the X-33 large-scale demonstrator and the X-34 small booster. In addition to the funds appropriated to NASA in FY 1995. the DoD has transferred $35 million to NASA, as directed by Congress, for the RLV program. This amount is reflected in the FY 1995 estimates for the RLV budget elements. These funds enable us to augment aerosciences, technology. concept development and preliminary design efforts which are key to a successful X-33 demonstration program.

In 1996 the RLV program will demonstrate on the ground the maturity of technologies critical to the December 1996 Single-Stage-To-Orbit (SSTO) flight demonstrator decision. The preliminary data base on candidate RLV systems/subsystem options must be sufficiently matured to support the X-33 decision. Among these technologies *are:* advanced. low-cost propulsion systems: reusable, light-weight cryogenic tanks and structures; light-weight and low-maintenance thermal protection systems: and vehicle health monitoring and maintenance systems within a highly operable vehicle system.

FY 1996 will be a critical year for the flight demonstration efforts. The DC-XA flight program will be completed by the integration of upgraded hardware into the vehicle. followed by a successful ground test and flight test of the integrated vehicle along with a comprehensive report on the performance of the technologies. The design of the X-34 small RLV booster will be completed and fabrication initiated. The selection of concept(s) for the X-33 advanced technology demonstrator will also be completed. The selection is to be based on the contractor's proposals for low cost ground and flight operations, sound business strategies/approaches, and scalability/traceability of the concept to show viability of an SSTO. The Administration's policy calls for a final decision on whether to proceed with the X-33 no later than December 1996.

Existing Launch Vehicle Systems

Major accomplishments in FY 1994 in the area of technology development and demonstrations to enhance existing launch vehicle systems include: development of an automated scheduling system for Orbiter processing at KSC, providing annual savings of $4 million: automation of Shuttle software verification at JSC. producing annual savings of $1.5 million and reducing verification time from 77 to 56 days for each flight: and continued improvements to the automated diagnostic capabilities in the JSC Mission Control Center through the application of diagnostic expert systems and pattern recognition techniques to automatically scan strip charts and raw telemetry.

Also in 1994. the Cooperative ELV activity has worked with industry on several Al-Li cryogenic tank projects. A low-cost extrusion process was developed to fabricate net shape (0.3inch thickness) Aluminum Lithium (Al-Li) wall panel sections for a 14 ft. diameter ground test article representative of an upper stage cryotank. Al-Li weld properties were optimized and automated welding was developed with real time, closed-loop process control. In addition, pathfinder Al-Li end ring frames for the 14-foot diameter test tank have been forged.

Other Cooperative ELV accomplishments in 1994 include qualification of a 60 HP quad-redundant electromechanical actuator in the MSFC load simulator. This actuator will be demonstrated in the SSME Test Bed by the end of FY 1995.

The SPIP continued to expand the database and analytical tools for evaluating nozzle materials, bondlines, and motor cases in 1994. The SPIP team also completed the 11-inch combustion simulator testing and finished the design of a large combustion simulator facility.

- In 1995, the Operations/Software activity will expand the application of automated scheduling beyond the Orbiter Processing Facility at KSC to include the Vehicle Assembly Building and the launch pads. Funds from this budget line will also be used to begin the development of an electronic documentation system at the JSC Mission Control Center. This documentation system will eliminate millions of photocopy pages and streamline the change procedures, with expected savings of $3 million per year. In addition, the Operations/Software funds will be used to apply model-based diagnostics for ground controllers to detect faults in the Shuttle's propulsion system and develop techniques for on-board health management.

In 1995, the Cooperative ELV activity will complete fabrication of low cost Al-Li components and finish a ground test rig for the Martin Marietta 14-foot diameter cryogenic tank tests. The team will utilize the Martin Marietta Integrated Fault Tolerant Avionics Facility to begin development of a stand alone, redundant EMA system (power source, actuator, fault tolerance and health monitoring) to meet Atlas Booster requirements. Moreover, SSME diagnostic system developments in use on the SSME Test Bed at MSFC, as well as trending techniques (feature extraction) algorithms developed by LeRC, will be applied to the development of an automated propulsion diagnostic system for ground checkout of the Atlas Booster.

The SPIP will complete the bondline inspection effort and complete testing of a 24 inch sub-scale combustion simulator in 1995.

For 1996, the Operations/Software effort will complete ongoing Shuttle-based demonstrations and begin focusing on supporting the automated systems requirements of the Reusable Launch Vehicle program. Most of the expert systems approaches applied successfully to current Shuttle needs are applicable to the next generation system. ARC will work directly with the RLV industry partners and MSFC to develop specific areas where their expert systems capabilities can be applied.

All cooperative ELV tasks (low cost Al-Li cryotank test at MSFC, end-to-end EMA simulation at Martin Marietta, and the automated diagnostics system demonstration at the Atlas Launch Complex) will be completed in 1996 and readied by the industry partner for transition to the Air Force's Evolved Expendable Launch Vehicle program.

Also in 1996, the SPIP will bring to closure the bondline thickness production prototype equipment and techniques, and will bring the contamination measurement equipment to a production demonstration level. Combustion simulator development activities will be 90% completed, including the first hot firing. Corrosion/contamination protection hardware and methods will be demonstrated. Alternates to the sole source nozzle materials will be evaluated. Selected infrastructure teams will be maintained as funding permits, and cultural enhancements and engineering products will be infused into flight programs.

In-Space Transportation

In-Space Transportation technology accomplishments in 1994 included the successful use of NASA-developed arcjet thrusters to keep a commercial (Telestar 4) satellite on station. Due to the significant fuel weight savings, such first generation arcjet systems

are now baselined on one type of commercial communications satellite. A qualification-level demonstration of a higher performance, 600-second specific impulse (Is_p) arc jet was completed under a NASA/industry program and accepted for the next generation GEO satellite series. A higher performance, 330-second Is_p chemical thruster has been demonstrated and baselined for another type of commercial communication satellite. The Solar Electric Flight Systems program was initiated to develop and flight test a 2.5-kilowatt ion thruster system for Earth-orbiting and planetary missions. Fabrication of a breadboard power processing unit was completed. Concepts for a high-fidelity ground simulation of automated rendezvous and capture capability have been formulated and a breadboard model of a video guidance sensor was completed.

In 1995. solar electric flight systems design and ground test efforts will continue, with a flight test planned before 2000 to demonstrate the readiness of electric propulsion technology as a primary spacecraft propulsion system. On-board propulsion will focus on low-power, light-weight systems for small spacecraft, including 500-watt arc jet life testing and feasibility of high performance monopropellant thrusters. Assessment of very advanced propulsion concepts will continue at a number of university labs.

In **1996,** In-Space Transportation activities will include completion of the first flight-ready solar electric thruster. For small satellite applications, a high pressure miniature chemical rocket, a flight-type Pulsed Plasma rocket, and a flight-type 0.50-kilowatt arc jet delivering 550-second Is_p will be demonstrated. Advanced propulsion concepts efforts will provide analytical and experimental evaluations of Carbon-60 as a propellant for ion thrusters and will produce a model of a Lorentz force accelerator. For Automated Rendezvous & Capture, a flight-qualifiable sensor system, a three-point docking mechanism, Guidance Navigation and Control software, GPS software and receiver, and simulation system and target assembly will be readied for ground testing.

BASIS OF FY 1996 FUNDING REQUIREMENT

SPACECRAFT AND REMOTE SENSING

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Earth applications systems	57,900	49,800	71.100
Space and planetary	55,800	50,500	60.100
Space platforms.	38,100	20,200	19,800
Partnership for next generation vehicle	2,500	5,000	7.000
Communications systems	29,000	18.800	19,500
(ACTS experiments and operations)	[7,600]	[3,000]	[3,000]
To	183.300	144.300	177.500

PROGRAM GOALS

The Spacecraft and Remote Sensing program has the primary goals of developing advanced spacecraft technology and systems concepts to reduce cost and increase performance of current and planned missions: to enable future missions: and to support the commercial development of space. The program also has the goal of establishing and maintaining technical expertise not only critical to the success of NASA's missions, but also valuable to the success of other government Initiatives.

STRATEGY FOR ING GOALS

The Spacecraft and Remote Sensing program encompasses a range of technology, from far-term basic research to identify and exploit major new scientific and technical discoveries, through more near-term focused efforts aimed at specific user needs. Organizationally, the program is focused along three general thrusts emphasizing the development and delivery of technology products. The first thrust, Earth Applications, focuses on scientific Earth observing systems technology to better understand global change and to develop commercial remote sensing as a viable new space industry. The second thrust is technology for space science missions, including space physics, deep space observation and planetary exploration. The final technology thrust supports developments for Earth-orbiting platforms such as occupied space stations. All three thrusts are supported by specific activities implemented through cross-cutting technology areas, including power and propulsion, materials and structures, operations. robotics, sensors and instruments and electronics and avionics.

In addition, NASA's efforts in the government-industry collaboration in automotive technologies, referred to as the Partnership for a Next Generation Vehicle (PNGV), are funded in this budget.. PNGV, established by the President and the "Big 3 U.S. Automobile manufacturers in 1993. is working to: (1) advance manufacturing technology to improve productivity: (2) develop technology to improve the emissions and economy of conventional automobiles over the next 3-5 years; and (3) design and develop technology

and production prototype vehicles to triple current fuel economy in a "Taurus/Lumina/Concorde" -like automobile within 10 years. NASA's role in the PNGV is primarily to develop advanced aerospace technology with direct application to the goals of the partnership. The agency also utilizes its systems experience to lead the PNGV systems analysis activity and guide overall investment in the most promising vehicle concepts and technologies.

In FY 1995, an overarching strategic change placed a much greater emphasis on enabling technology for the next generation of planetary, Earth observing and space science spacecraft. These spacecraft are envisioned to be much smaller than traditional 1000 kg-class spacecraft, will be launched on small to medium launch vehicles, and will also be much more autonomous than current spacecraft to greatly reduce overall life-cycle cost. A key element of this technology effort in FY 1996 will be a strong emphasis on microsystems (instruments, avionics, etc.) to preserve spacecraft and payload performance concurrently with the reduction in spacecraft cost and size.

The space communications program area is advancing critical communications technologies to support commercial needs and NASA science and exploration missions for the 1990's and beyond. In addition to its own R&D efforts, the space communications area will advocate the development of related technologies in order to utilize advances in other spacecraft technology areas, such as propulsion and power systems, for the benefit of the space communications industry.

The space communications area is organized into three major program elements: Near Earth Communications: Deep Space Communications/Terrestrial Hybrid Systems: and Applications Experiments. The Near Earth Communications research program element explores Radio Frequency (RF), digital and mobile communications systems technologies in support of the commercial space communications industry and the needs of NASA's Mission to Planet Earth. The Deep Space Communications sub-element develops technologies primarily to meet the needs of special NASA missions for planetary exploration and astrophysics. The Space/Terrestrial Hybrid Systems sub-element investigates the space communications portion of hybrid satellite/terrestrial systems, such as those to be utilized by the National Information Infrastructure. The Application/Experiments budget element supports technology demonstrations of new or improved communications services, primarily through the use of the Advanced Communications Technology Satellite (ACTS). The ACTS experiments program is the centerpiece of the nation's advanced communications development activities. emphasizing strong participation by U.S. industry and the transfer of ACTS technologies to U.S. industry. ACTS is expanding capability and reducing costs through technology developments and advancements, thus increasing U.S. competitiveness in communications systems and spacecraft performance.

Significant co-investment by industry is a basic tenet of the Spacecraft and Remote Sensing program. Across all Spacecraft and Remote Sensing technology efforts, industry is expected to contribute more than 15% of total resources applied. Substantially greater private investment will made in two programs: the PNGV and the Commercial Remote Sensing Program (CRSP). All PNGV activities will be co-funded by NASA and industry at approximately equal levels (except in system analysis, where NASA will accept about 70% of the burden on behalf of the government partners). Projects selected within the CRSP will also be co-funded by industry at levels about equal to the NASA investment. Currently, the typical level of industry co-funding for CRSP projects selected is over 50%.

Other innovative management techniques are being utilized by the Space Environments and Effects program within the Space Platforms budget element. Instead of providing base R&D funding to NASA centers, the program used a competitive NASA Research Announcement open to both NASA and non-NASA organizations. A unique set of criteria was used for selection: proposals were evaluated in large part (40% of the score) based on customer rankings of technology needs.

- NASA integrates the broad range of its Spacecraft and Remote Sensing activities by bringing together and balancing the efforts of a number of NASA facilities and a large cross-section of aerospace companies and universities. The NASA Centers involved are Langley, Lewis and Ames Research Centers, Johnson and Stennis Space Centers, and Marshall and Goddard Space Flight Centers, as well as the Jet Propulsion Lab. Major industry participants include CTA, TRW, Ball Aerospace, Martin-Marietta, Lockheed, Hughes and Motorola. University contributors include Auburn University, the University of Texas, Carnegie-Mellon University, the University of Maryland, the Massachusetts Institute of Technology, Stanford University and Pennsylvania State University.

MEASURES OF PERFORMANCE

Complete three preliminary PNGV definitions vehicle September 1995	System-level hybrid vehicle studies will be initiated to assess technology requirements for the next generation vehicle. The first major milestone of these studies will be preliminary definitions.
Ground testing of integrated space solar dynamic power system 1st Quarter, FY 1995	Ground testing is required on budget and 8 months ahead of original schedule to meet Shuttle-Mir flight test schedule.
Complete contamination control guideline for spacecraft design 4th Quarter, FY 1995	The guideline will increase reliability and reduce costs for designing spacecraft by providing design rules to control contamination to levels required for mission success.
Complete development and testing of new spacecraft thermal coatings 4th Quarter, FY 1995	These new white and black, tailorable, electrically conductive, thermal control coatings will increase spacecraft life and reliability by mitigating charging and plasma effects from electrical grounding.
Complete integration of databases for space environment effects and materials 4th Quarter, FY 1995	These databases will reduce costs and increase the accuracy of spacecraft design margins.

ACTS Broad-band aeronautical terminal experiments begin October 1995	A unique capability in live video and data transmission for commercial aviation application will be demonstrated
Complete the development of a high-efficiency (50%) Traveling Wave tube (TWT) for Ku-Band (12-14 gigahertz (GHz)) for commercial satellite applications February 1996	By increasing TWT efficiency from 35% to 50%, power and weight requirements would be reduced, allowing significant increases in spacecraft capability or reduced launch costs. In either case, the competitiveness of the commercial satellite industry would be enhanced.
Cryogenic optical and random vibration testing of a fully integrated infrared telescope test-bed 2nd Quarter FY 1996	This technology supports the Space Infrared Telescope Facility (SIRTF) as well as other missions that require lightweight, high performance optics.
Complete development of a 155-Mbps, high-efficiency, Integrated Services Digital Network (BISDN) modem July 1996	Efficient digital communications systems for the National Information Infrastructure (NII)/ Broad Band Global Information Infrastructure (GII) will be demonstrated.
Mars Pathfinder micro-rover completed and flight qualified 4th quarter FY 1996	The first micro-rover spacecraft to be flown, it will pave the way for future planetary exploration missions utilizing small rover systems.
Initial demonstration of a 800-gigahertz local oscillator with planar diodes for sub-millimeter astrophysics applications 4th Quarter FY 1996	Sub-millimeter heterodyne astronomy missions will be supported by providing planar diodes that are more reliable and easier to manufacture.
Complete development and demonstration of a breadboard refrigerator/freezer for Space Station 4th Quarter FY 1996	This breadboard refrigerator/freezer is the prototype for the unit required to store biological specimens on the Space Station.

Deliver design guidelines for electromagnetic compatibility of composite structures 4th Quarter FY **1996**	These first guidelines for grounding and bonding composite materials will increase reliability and reduce costs for designing and building spacecraft using composites.
Deliver design guidelines for safety-critical circuits 4th Quarter FY **1996**	These guidelines will provide the first common basis for design and analysis of safety-critical circuits, reducing costs and improving designs.
Complete a prototype package and power system for a micro-weather station for high-altitude Earth aircraft and Mars applications 4th Quarter FY **1996**	This effort will demonstrate the first high-payoff, micro-electromechanical **(MEMS)** technology to be utilized for a space application focused on **Mars** and **Earth** science goals.
Demonstrate a high performance integrated "camera-on-a-chip" active-pixel sensor 4th Quarter FY **1996**	This low-power, low-manufacturing-cost, imaging technology relates directly to the potentially high-volume markets such as home and digital commercial video, computer imaging, and medical imaging.
Test the components for an integrated free-flying magnetometer "spacecraft-on-a-chip" 4th Quarter FY **1996**	Multiple, very small (silver dollar size) independent sensor systems, (with sensor, data telemetry and battery power integrated onto single, chip-sized spacecraft) that can acquire science data and relay it back to a primary spacecraft will be demonstrated.
Complete Ranger spacecraft 4th Quarter FY **1996**	A multitude of advanced robotics technologies, including advanced ground control, autonomous operations, telepresence control, low-cost manipulator systems, hybrid propulsion, and robotic servicing technologies will be demonstrated on this spacecraft.
Conduct demonstrations of autonomous 100-acre robotic crop harvesting 4th quarter FY **1996**	A new agricultural robotics product line that will impact an international market will result.

Complete development of a 20-GHz System-Level Integrated Circuit (SLIC)/Monolithic Microwave Integrated Circuit (MMIC) 4-element phased array antenna system.	This work will support the satellite industry in developing less expensive satellite antennas.
• September 1996	

ACCOMPLISHMENTS AND PLANS

Each budget element funds cross-cutting efforts, as well as programs within its own area of responsibility.

Earth Applications Systems

In FY 1994, two radar flights and the successful flight of the Laser In-space Technology Experiment (LITE) on the space shuttle opened a new era of active Earth sensing. These developments, along with delivery in FY 1995 of an eye-safe laser transmitter for evaluation on the laser wind-sensing testbed, have laid the groundwork for an effort to reduce the mass and size of active (laser and radar) sensing instruments and make them compatible with the new paradigm of small space missions. In addition, in FY 1995, design guidelines for using advanced composites in spacecraft structures will be completed and distributed, giving designers confidence in the use of these materials. Potential technology candidates to replace pyrotechnics on spacecraft will also be assessed in FY 1995 to try to increase spacecraft safety. Advanced tools for low-cost jitter analysis will be delivered to industry in FY 1995 to improve spacecraft designs by allowing jitter effects to be discovered early in the design process.

In FY 1996, NASA will place increased emphasis on developing the sensor and instrument technology for compact, low-cost space radar systems that can be used with small spacecraft (incorporating deployable arrays) to increase the spectrum of space-based Earth observations. A prototype integrated composite optical bench and instrument casing will be completed in FY 1996. This structural article will be utilized by the Spectroscopy of the Atmosphere Using Far Infrared Emission (SAFIRE) instrument. but will be applicable to many lightweight Earth-observing instruments. Other 1996 activities include demonstration of low-cost carbon-carbon manufacturing of complex spacecraft component shapes, a trade study of advanced solar arrays and delivery of a prototype instrument vibration isolation system for Earth-observing spacecraft.

Space commercialization will be promoted by continued support for the Commercial Remote Sensing Program (CRSP). The CRSP is the only government program focused specifically on working with the commercial sector to develop remote sensing as a viable space industry. To date, the program has involved over 150 participants in more than 50 projects. In FY 1994. 12 cooperatively funded awards were made as part of the Earth Observing Commercial Application Program (EOCAP), and eight more new awards were made in FY 1995 (six of which were to small businesses). In FY 1996. CRSP will continue with an emphasis on exploiting the technology products and opportunities offered by the two *SSTI* spacecraft. Currently, about *25* projects have been identified to transfer this capability to industry.

Space and Planetary

In FY 1994, NASA competitively selected an industry concept for an advanced infrared telescope with twice the collecting area, half the mass, and one third the diffraction-limited wavelength of the previously flown Infrared Astronomy Satellite (IRAS). In FY 1995, an infrared telescope technology test-bed will be delivered to the JPL cryogenic optical test facility. In FY 1996. the test-bed will undergo cryogenic optical and random vibration testing. This technology work is critical to the development of the planned Space Infra-Red Telescope Facility (SIRTF) initiative in the Space Science program.

In FY 1995, OSAT will complete assembly of a 10-kilogram(kg) micro-rover for the Mars Pathfinder mission. The rover will be used to provide images of the lander to assess its condition on the planet's surface. The rover will also carry an alpha-proton-x-ray spectrometer to determine the composition of rocks and soil samples, and it will conduct multiple technology experiments to lead the way for routine use of small rovers to explore Mars. By the end of FY 1996. the micro-rover flight unit will be space-qualified and delivered for integration into the Mars Pathfinder spacecraft in preparation for a scheduled December 1996-January 1997 launch.

Space Platforms

In FY 1994, analysis of data from the Long Duration Exposure Facility (LDEF) was completed. The LDEF data analysis is one component of the larger technical area of space environment and effects. The Space Environment and Effects program was initiated in FY 1995 as a follow-on to LDEF and is focused on reducing the design and operations margins needed to account for uncertainties in the environment and effects of space. Products delivered in FY 1995 include: a contamination control guideline for the design of spacecraft; the completed development of white and black, tailorable, electrically conductive, thermal control coatings: and an integrated database for environmental effects and spacecraft materials. The coatings are particularly noteworthy, because no conductive coatings have been available before *this* time to reduce either the structure floating potential or spacecraft charging (a significant cause of spacecraft failures in geosynchronous orbit). In FY 1996, customers will receive design guidelines for safety-critical circuits, as well as for electromagnetic compatibility when using composite structures. Without these guidelines. each program has been determining its own, independent approach for the design of safety-critical circuits, and program managers have been reluctant to use the lighter-weight composite materials due to lack of information about procedures for use in spacecraft design. The safety-critical circuits work is a joint effort with the Office of Safety and Mission Assurance (Code Q), with funding in this budget element to be used for technology testing and development.

Among the other Space Platforms accomplishments and plans for FY 1995 is the first ground test of an integrated space solar dynamics power system. Due to the criticality of the test results to the solar dynamic flight experiment on Shuttle-Mir, the testing was accomplished in early FY 1995, eight months ahead of schedule, and on budget. A contract for the demonstration and delivery of a breadboard prototype refrigerator/freezer for biological specimens for Space Station was also initiated in FY 1995. The development and demonstration of this breadboard prototype will be completed in FY 1996, allowing construction of flight units based on the results of prototype testing.

Partnership for a Next Generation Vehicle

Several projects have been developed between NASA and the automobile manufacturers that are planned to continue through FY 1996. NASA and industry partners will develop advanced engine sensor technology based on NASA work in silicon-carbide electronics for aircraft applications. The team will develop a concept for a thermoelectric generator to reduce engine loads, based on work previously conducted by NASA for space nuclear power generation. An improved. fast starting catalytic converter system using technology developed for the space shuttle thermal protection system will be pursued to reduce engine emissions. Metallic coating technology to reduce cylinder blow-by, using technology developed for rocket engines, will also be examined. Finally, for hybrid electric vehicles, the partners will work on advanced power electronics based on technology developed for fly-by light. power-by-wire aircraft, for the space station power system and for advanced spacecraft power management systems. NASA will also continue to lead the PNGV systems analysis activity to guide overall investment in the most promising vehicle concepts and technologies.

Space Communications

By the end of FY 1995, the space communications program will have accomplished an extensive number of ACTS experiments. Some of the most unique experiments will have been performed in the areas of tele-medicine. tele-education and demonstration of high-data-rate transmission via satellite. In FY 1995. the high-data-rate terminals will be completed and the experiments started. The experiments are at data'rates from 155 Mbps to 622 Mbps. This is the first time that such data rates will have been transmitted through satellites. Under the technology program during FY 1995. the development of the Broad-Band Aeronautical terminal will be continued for use in experiments with ACTS in FY 1996. This element of the program involves the airlines and the commercial aircraft industry. The program has already demonstrated the feasibility of 20 GHz System Level Integrated Circuit (SLIC)/MMIC antenna systems. In addition, the digital portion of the program has completed the development of a very high data rate (800Mbps/450 megahertz (MHz)) modem. The Optical communications Phase A study has been completed by the two industry teams (led by Motorola and Ball Aerospace). Moreover, the technology program is focusing the research elements. with inputs from industry, to address technologies needed to support the role of satellites in the national information infrastructure (NII)/ global information infrastructure (GII).

Cross-Cutting Activities

Among the cross-cutting activities, the space power program will develop component technology and systems concepts for high-efficiency, compact power systems. The program is focused on solar power generation, chemical storage, thermal management, environmental interactions and power management and distribution. In FY 1995, program emphasis was directed toward applications for small, low-cost, Earth-orbiting and planetary spacecraft. In FY 1996, an advanced power system architecture will be developed for a technology flight experiment. This architecture is highly modular, fault tolerant and scaleable. In the laboratory, this design has demonstrated performance levels of 97% efficiency over a power range of 0.5 kilowatt (kW) to 5.0 kW. This compares with an average efficiency of 90% over this range for current systems. In support of deep space and planetary surface missions, electronic devices capable of operating at 10 degrees Kelvin (K) will be characterized and an advanced power

converter, compatible with electric propulsion systems, will be demonstrated to be capable of operating at temperatures 50 degrees Celsius (C) higher than current systems.

In another cross-cutting effort. the sensors and instrument program will continue to work with industry, universities, and other government laboratories to develop instrument technologies for Earth and planetary science, astrophysics and space physics applications. Demonstrations in FY 1994 and 1995 of large-format infrared arrays with improved producibility for both Earth science and astrophysics mission applications will enable the shift in emphasis to new areas in FY 1996. These include development of uncooled infrared arrays as well as large-format visible, ultraviolet, x-ray, and high-energy detector arrays. For sensitive astrophysics observations. demonstration (ahead of schedule) in FY 1994 of a 600-GHz sub-millimeter mixer enabled continued progress towards an 800-GHz capability in FY 1996. For Earth science applications, the development in FY 1995 of several local oscillator approaches for the measurement of the hydroxyl radical at 2.5 terahertz will lead to development of the most promising approach in FY 1996. Development of micro-electromechanical systems (MEMS) components in FY 1994 and 1995 will be followed in FY 1996 by the completion of a prototype package and power system for a Mars/Earth upper atmosphere micro-weather station. demonstration of a high performance integrated 'camera-on-a-chip" active pixel sensor for miniature imaging systems, and test of the components for an integrated free-flying magnetometer 'spacecraft-on-a-chip."

The cross-cutting operations program is focused on reducing overall mission costs by improving operations of both spacecraft and ground systems. The program encompasses artificial intelligence applications to reduce direct dependence on human operators. The operations program also supports advanced data analysis and retrieval technologies to improve the return and extraction of both science data and operating performance data. which contain critical information on spacecraft health. In FY 1994, the Extreme Ultraviolet Explorer mission operations office validated automated monitoring technology developed by this program to reduce the total spacecraft operator hours by 60%. In FY 1995, the program was refocused on technology for small. highly autonomous spacecraft. In FY 1996, technology will be demonstrated to fully standardize space mission control architectures for a completely autonomous, small spacecraft. Mission control functions to be automated include onboard command sequence development and validation for autonomous maneuvers and science instrument control. as well as techniques for onboard reduction and down-linking of data with a million-to-one reduction in down-link costs.

In FY 1996, the robotics and space materials/structures/environmental effects cross-cutting programs will primarily emphasize applications for Earth orbiting platforms. Specifically, the robotics program will complete the development and integration of the Ranger spacecraft, in preparation for an early FY 1997 launch. Ranger will be an advanced technology flight experiment which will demonstrate technologies for robotic spacecraft servicing, remote ground control, Space Station servicing, and commercial space operations. The robotics program will also continue development of the next generation of planetary surface micro-rovers, targeting a 50% reduction in rover mass and volume. In addition, the program will initiate development of a set of new technologies for planetary and small-body sample collection and preservation. In FY 1996, the space environmental effects program will deliver a conductive paint to dissipate harmful electrical charges from spacecraft. This will be one key near-term product of an NASA Research Announcement (NRA) that selected 19 projects in FY 1995. Also in FY 1996. six space environmental experiments will be flown, and construction of a materials exposure facility will be initiated to be flown early in Phase II of the International Space Station.

BASIS OF FY 1996 FUNDING REQUIREMENT

ADVANCED SMALLSAT TECHNOLOGY

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Small spacecraft technology initiative	12,500	61,900	33,900

PROGRAM GOALS

The major goals of the Small Spacecraft Technology Initiative *(SSTI)* are to demonstrate how to reduce the cost and development time of space missions for science and commercial applications; to demonstrate new design and qualification methods for small spacecraft, including use of commercial and performance-based specifications and integration of small instrumentation technology into bus design: and to proactively promote commercial technology applications.

STRATEGY FOR ACHIEVING GOALS

NASA is capitalizing on recent U.S. industry technology developments in the early generations of light-weight satellite concepts and critical subsystem component technology. These developments have demonstrated the potential capability for small spacecraft design methodology to greatly reduce the cost of civil and military space missions. At the present time. international competition to design and launch more advanced commercial spacecraft for remote sensing and communications is impacting market opportunities for current products of the U.S. space industry. This major national effort will exploit the "next generation" of miniaturization techniques for spacecraft components. advanced instrumentation. and sensors in order to integrate them into U.S. advanced design concepts.

By utilizing highly integrated teams of industry, small business, academia, and government technologists, *SSTI* will demonstrate on-orbit, in a fast-track time frame, advanced technologies for future space systems and will develop new ways of conducting business that are unfettered by government specifications and excessive oversight. The advancement of small spacecraft technology also provides a mechanism to establish new opportunities in technology transfer for development of commercial products. The industrial sectors for possible commercial applications include transportation, medical, manufacturing. and consumer products. *SSTI* includes a focused effort on proactive insertion of technology into new commercial products and creation of new business opportunities for U.S. companies. This program will greatly enhance the competitive position of the U.S. spacecraft industry in the world space market in addition to enabling lower cost and more frequent space missions.

NASA currently has contracts for the design, development, production and launch of two advanced smallsats. The "Clark" spacecraft is being built by CTA Incorporated of Rockville, Maryland. The "Lewis" spacecraft is being built by TRW and managed out of their Chantilly, Virginia office. These innovative, cost-plus-incentive-fee contracts contain clauses which should mitigate any cost overruns. For example, for every dollar the contractor overruns, an equal amount will be reduced from the available fee,

and for every month that the contractor does not meet the launch date, one sixth of the available fee will be reduced. The integrated development team concept was emphasized. This resulted in a significantly larger percentage of small and small disadvantaged business involvement.

- **MEASURES OF PERFORMANCE**

Mission Operations Plan/ Design Reference Mission 1st Qtr. FY 1995	Must have a clear agreement on the mission and the operations of the mission early enough to establish a data collection policy, a data archiving system, and a spacecraft tasking policy.
Detail Design Concurrence 1st Qtr. FY 1995	Early concurrence of the detailed designs is critical to the process of building a spacecraft. The designs must be frozen in order to build the spacecraft without schedule slippage and cost overruns.
Industry Workshop on Spacecraft Design 3rd Qtr. FY 1995	This milestone is necessary to fulfill the commitment to the spacecraft industry that NASA would share the spacecraft design processes being implemented.
Instrument Acceptance/Delivery 1st Qtr. FY 1996	Instrument acceptance and delivery at this time is critical to meeting the flight schedule.
Concurrent Integration Complete 2nd Qtr. FY 1996	Completion at this time is necessary to meet the flight schedule. A small schedule contingency currently exits to accommodate any small, last minute schedule adjustments.
Ship both Spacecraft to Launch Site & Launch Site Operations 3rd Qtr FY 1996	Shipment of the spacecraft at this time is necessary to allow sufficient time to mate the spacecraft with the launch vehicle and prepare for the launch.
Launch of both Spacecraft June & July 1996	Adherence to this milestone allows NASA and industry to meet the commitment for a 24-month period between contract initiation and launch of the spacecraft and provides the primary metric for determining the amount of any award fee.
Initial On-Orbit Operations 4th Qtr. FY 1996	Initial on-orbit operations must begin at this time to meet the terms of the contract and meet the urgent need for timely Earth observation data.

ACCOMPLISHMENTS AND PLANS

The contracts for the two spacecraft were signed in June and July 1994. They are being managed out of NASA Headquarters by a small program office of about five full-time-equivalents.

In FY 1995, the detailed design will be frozen and hardware will be built. A spacecraft industry workshop on spacecraft design will be held, which will share the design processes being used for SSTI. Two-thirds of FY 1996 will be utilized to complete the integration of all systems, technologies, and instruments on the spacecraft. Lewis and Clark will be completely tested, delivered, and integrated with the launch vehicles at the launch site. Launches are planned for June and July 1996 for Clark and Lewis, respectively. Initial on-orbit checkout of the spacecraft will be completed during the 4th quarter of FY 1996, as will the initiation of experiments.

BASIS OF FY 1996 FUNDING REQUIREMENT

SPACE PROCESSING

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Materials processing..	11.800	11,000	10,900
Biotechnology..	7.700	7,300	7.200
Space station utilization	--	[15,000]	[37,100]
To	19 500	18 300	18,100

PROGRAM GOALS

The Space Processing program has three major goals. The first goal is to foster the development of new products using the unique micro-gravity and vacuum attributes of space. These new products can either be produced in space, or be the result of new approaches to ground-based commercial technologies using insights gained from space flight. The second Space Processing goal is to increase U.S. business participation and investment in space-linked commercial goods and services in order to benefit the U.S. industries involved and the economy as a whole. The third space Processing goal is to provide the opportunity for students to -gage with industry in space program activities.

STR FOR CHIEVING GO

The Space Processing program is conducted in partnership with industry, universities, state governments and other Federal agencies. The program's purpose is to increase the number of products and services that utilize the attributes of space. To reach new partnership agreements, the program will use the Centers for the Commercial Development of Space (CCDSs), specific project centers, such as Vanderbilt University. and several NASA field centers (Ames. Langley and Lewis Research Centers and Marshall Space Flight Center). These program bases at universities and NASA field centers provide excellent opportunities to seek numerous and varied industrial affiliations. The Space Processing program provides the required access to experiment facilities and offers frequent access to space, utilizing the Shuttle mid-deck. SPACEHAB. Spacelab and Wake Shield facilities. Such access is prohibitively expensive for most single corporations or small business, and this barrier to entry has greatly retarded the commercial development of space-linked products. Through the cost-sharing partnerships between NASA, the universities and industry offered by the Space Processing program, private enterprises of all sizes are able to afford the research most important to the development of space-linked commercial products.

MEASURES OF PERFORMANCE

Alpha Interferon Experiment STS-63 and STS-70 February 1995/June 1995	This protein crystal experiment, carried out by the CCDS at the University of Alabama-Birmingham and industry partner Schering-Plough, could result in a more efficient treatment for such diseases as leukemia, Kaposi's sarcoma venereal warts and chronic hepatitis B and C.
Micro-encapsulation of Pancreatic Islets for Diabetes Large animal trials begin April 1995; Small animal trials end, October 1995	This project at Vanderbilt University will isolate and micro-encapsulate pancreatic islets to allow improved treatments for diabetes. Transplantation of encapsulated islets has already been accomplished in small animals, with large animal transplants the next step.
Flight experiment to develop new contact lens material on STS-63 February 1995	Langley Research Center and industry partner Paragon Vision Sciences Corporation are working to develop a better contact lens material with greater stability, increased oxygen flow and greater retention of liquid.
Metal Sintering Experiment on STS 63 February 1995	The CCDS at the University of Alabama-Huntsville (CMDS) is working with industrial sponsors, including Kennametal, and Wyle Labs, to improve knowledge of defect-trapping behavior under micro-gravity conditions for sintered composites. The information will improve tool quality, thus leading to greater competitiveness of the U.S. machine tool industry.
Wake Shield Facility on STS-69 July 1995	The CCDS at the University of Houston (the Space Vacuum Epitaxial Center (SVEC)) and industrial sponsors such as AT&T Bell Labs and American X-tal Technology are using this re-flight of the Wake Shield Facility for epitaxial growth of high-quality. thin-film semiconductors in "ultra vacuum." Applications include advanced, high-speed optical and high-frequency devices.
Zeolite crystal growth Spacelab experiment September 1995	Marshall Space Flight Center and Worcester Polytech Institute will be growing enhanced zeolite crystals during this flight. These crystals would have application in the petrochemical, electronics, oil and water treatment industries.
Develop first Factor D compound for clinical trials December 1995	The CCDS at the University of Alabama-Birmingham is working with Bio Cryst to produce this compound in-vitro in order to create a drug to enhance immune system capabilities. Phase I clinical trials will be at their mid-point by December 1996.

Develop drug to combat Influenza Virus Neuraminidase. First compound to clinical trials December 1995.	The CCDS at the University of Alabama-Birmingham is working with Bio Cryst to design a more efficient, less toxic drug to combat this virus. The work will require a series of Shuttle flights in 1995 and 1996. Phase I clinical trials will be at their mid-point by December 1996.
First clinical trials using space technology Light Emitting Diodes (LEDs)for medical purposes January 1996	LEDs initially developed by the University of Wisconsin-Madison for plant growth in space have led to new medical devices by industry partner Quantum Devices Inc., which offer potential for treatment of psoriasis and brain cancer.

ACCOMPLISHMENTS AND PLANS

In FY 1994, the Space Processing program completed 24 flight experiments utilizing Shuttle mid-deck lockers, SPACEHAB. and the first flight of the Wake Shield Facility. These experiments provided information for technology developments in several industrial areas, including pharmaceuticals, medical devices, agriculture, ceramics and metallurgy. For example, the growth of protein crystals in space allowed the characterization of alpha-interferon and Factor D, which could result in advanced drugs. As a result of another experiment, the encapsulation of pancreatic islets could lead to new treatments for diabetes.

In FY 1995, the second flight of the Wake Shield Facility will demonstrate epitaxial growth in free-flyer mode. The flights of Spacehab-3 and USML-2 will include experiments involving protein crystal growth. metal sintering, physiological testing, fluids mixing, biomedical applications, zeolite crystal growth, and plant growth. In the protein crystal growth experiments, an attempt will be made to regulate the growth of the alpha-interferon crystal, thus yielding a more effective, slower-released protein for pharmaceutical use. Work on polymers could result in clinical trials of new contact lenses developed by Paragon Vision Sciences Corporation. The ECLIPSE liquid metal sintering experiment scheduled for SPACEHAB-3 will process samples for a full hour, a duration essential for providing the defect trapping information which will enable comparisons with sintering processes on Earth.

In FY 1996, additional proteins will be flown and characterized to provide design data for better drugs for human use. In the continuation of the diabetes micro-encapsulation project, larger animal trials will begin bringing us closer to understanding the dynamics that are necessary for human trials. The clinical trials of photo-kinetic therapy using a Light Emitting Diode (LED) light source to treat a psoriasis will be concluded. The SPACEHAB-4 flight is expected to provide float zone single crystals of GaAs and GaSb for advanced electronic applications such as faster computer processing.

In addition to the near-term applications, the Space Processing program plans to work with its centers and their industrial partners to capitalize on the results from these experiments to complete planning for the commercial utilization of the Space Station. The intent is to focus resources on those applications and processes which show the greatest possibilities for commercial success.

BASIS OF FY 1996 FUNDING REQUIREMENT

FLIGHT PROGRAMS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Program definition	500	--	--
Flight experiments (in-space tech experiments program)	29,100	30.600	30,100
Space station utilization	--	15.000	37,100
Experiment carriers and transporters	107.200	2.000	8.100
COMET	21,700		
CMAM	85,000		8,100
Sounding rockets/aircraft	500	2,000	
Experiment preparation, integration & mission management	4,100	1,500	700
To	140 900	49 100	76,000

PROGRAM GOALS

The primary goal of the Flight Programs budget element is to support the development and launch of flight experiments which will validate advanced space technologies. promote the creation of new knowledge, expand learning opportunities for students. and produce new jobs, products, and industries. The primary goals of the In-Space Technology Experiments Program (IN-STEP) funded in the Flight Experiments budget element are: to reduce the cost and risk associated with future space missions: and to improve U.S. Industry competitiveness by developing and operating the innovative flight experiments required to validate advanced technologies or investigate space environmental effects. A secondary goal of the IN-STEP is to support U.S. educational objectives through the use of the "fast-track" student experiment program.

The goal of the Space Station Utilization program is to support the development and operation of space processing and technology research using space stations as long-duration orbital facilities. The long-duration space experiments created by the Space Station Utilization program will allow development of new products for both aerospace and non-aerospace applications. and for both commercial and government use. An additional goal for the Phase I Space Station experiments is to reduce risk for follow-on Phase II/III Station experiments.

The goal of the Commercial Mid-deck Augmentation Module (CMAM) contract with SPACEHAB. Inc. is to stimulate industry participation and investment in the commercial development of space by providing additional mid-deck-type accommodations.

TRATEG FOR A GOALS

In FY 1996, almost 90% of the Flight Programs funding supports the development of flight experiments in the IN-STEP and Space Station Utilization programs. The remaining 10% of the funding provides for the balance of the accommodations leased in the SPACEHAB Commercial Mid-deck Augmentation Module (CMAM).

Periodic open, competitive solicitations are utilized to ensure that the best, most innovative. and most relevant experiments from industry, academia, and government agencies *are* selected for the IN-STEP program. The open competition also ensures the opportunity for diverse involvement in the program. IN-STEP experiments are selected through a peer review competition based on technical categories and requirements developed in consultation with industry, other government agencies, and NASA program offices. At the end of the definition phase, the experiments are reviewed by an independent panel for relevance, performance, cost, and schedule to determine if they should be authorized to proceed into the next phase of development (i.e., Phase C/D). If an experiment is projected to exceed either its cost, schedule. or performance guidelines, a special review is conducted to consider termination of the experiment. In addition. a "fast track" category was established in the 1992 IN-STEP solicitation that provides graduate students the opportunity to develop and fly space experiments to satisfy the needs stated in the solicitation as well as to support their educational plans (e.g. doctoral thesis). These "fast track" student experiments are peer-reviewed and ranked with the non-student proposals but are limited to a development cost and schedule of $200,000 and two years respectively.

The Space Station Utilization program is organized into three phases. In Phase I. experiments will be selected and flown on the Shuttle-Mir flights to reduce risk and validate technology for Phase II/III International Space Station systems and payloads, as well as to conduct space processing research. Phase I will include eight Shuttle-Mir payloads. most of which use existing hardware or processes. As a result. one major challenge is to accommodate unique Mir integration and operational requirements while delivering high-quality hardware on schedule. Two of the payloads also require coordinated ground preparation with the Russians: The first is the Liquid Phase Sintering Experiment which uses a Russian furnace. The second, the Energy Module (Solar Dynamics), is funded jointly by Space Access and Technology and the Space Station programs. The joint development with the Russian Space Agency and includes both U.S. and Russian hardware. Each payload will be provided a set of milestones established by the Space Station program. The cost and schedule performance for each payload will be monitored closely to ensure that the milestones will be met with quality hardware, on time and within budget.

The Phase II/III Space Station Utilization program involves two main thrusts. The first is to select and develop space processing and technology payloads, and the second is to define and develop common lab equipment and facilities for use on-orbit by payloads from multiple sponsor organizations. The Phase II/III payload selection process is designed to ensure that the mission and goals of the NASA Strategic plan and the Space Technology Enterprise are supported by the selected payloads. Moreover, Space Station Utilization planning will be done in close coordination with other user organizations to ensure optimum use of NASA resources. The common equipment and facilities will also be developed in close cooperation with these other organizations. For example, the NASA Offices of Space Access and Technology and Life and Microgravity Science and Applications have already defined a common set of lab equipment, including a special Space Station EXPRESS rack that will facilitate and speed the preparation of payloads for launch.

The Space Station Utilization program goal will be achieved by involving all sectors of the US technology development community through industry/university/government partnerships. The Centers for the Commercial Development of Space are university/industry/government partnerships. They are usually centered at a university, which receives a modest grant from NASA, provides expertise and serves as the focus for industry to extend their R&D into space. The Centers receive a significant percent of their resources for this program as cash and in-kind services from industry. Access to space is extremely expensive in the context of industrial R&D; however, the attributes of space cannot be duplicated effectively on the ground. Thus, industry must have space access to develop their unique products or to obtain data leading to the development of such products. The Space Station Utilization program encourages the teaming of a number of industrial. university and government organizations by providing them access to space for a relatively modest investment of cash and/or in-kind services.

The strategy for implementing the Flight Programs budget includes a series of management targets aimed at attaining the most return for the government's investment. One of these targets is that experiment results will be successfully transferred to the user and baselined. or used in future commercial endeavors or NASA missions, within two years from completion of the experiment. In addition. a minimum of 60% of IN-STEP funds will be provided to industry and universities, and experiment developers will reflect the diversity of America and include both big and small businesses and universities. The IN-STEP program must also be in compliance with agency goals for cost and schedule control. Similarly, the CMAM contract of leased accommodations must continue within cost and the two SPACEHAB/CMAM missions must perform successfully. *Finally.* the results of the "fasttrack" student experiments must provide valuable information to both *NASA* and industry and the results must be used to support student doctoral theses.

MEASURES OF PERFORMANCE

SPACEHAB-03 commercial experiments February 1995	SPACEHAB flights provide access to space for continued validation of various new commercial technologies and for Space Station risk reduction experiments.
Mir Optizon furnace experiment procedures developed in Russia February 1995	NASA researchers will work with the Russians to prepare for the use of a Russian Optizon furnace in the Liquid Phase Sintering metallurgy experiment.
Initial EXPRESS Rack delivered April 1996	This rack will be flown on the Shuttle to validate the fast and easy payload integration planned for the Space Station.
OAST Flyer mission on STS-72 September 1995	IN-STEP experiments will obtain the first actual measurements of space contamination, demonstrate an innovative technology to provide autonomous closed-loop control of spacecraft. and validate a new inflatable antenna technology to reduce mass and volume.

Energy Module (Solar) Dynamic hardware shipped to Russia for integration February 1996	This is a joint NASA/RSA risk mitigation experiment.
Might of Commercial Generic Bioprocessing Apparatus with industrial samples on STS-76 March 1996	This facility will be used to validate a number of new commercial bioprocessing technologies to meet the needs of the pharmaceutical and agricultural industries.
Liquid Phase Sintering experiment on Shuttle-Mir Mission 3 (STS-76) March 1996	This metal sintering experiment will use the Russian Optizon furnace to investigate the defect-trapping behavior of sintered metals in micro-gravity.
SPACEHAB-04 commercial experiments April 1996	SPACEHAB flights provide access to space for continued validation of various new commercial technologies and for Space Station risk reduction experiments.
Commercial Protein Crystal Growth experiment on Shuttle-Mir Mission 4 (STS-79) August 1996	This experiment will further develop capabilities to grow unique protein crystals in space.
Materials in Devices as Superconductors experiment on Shuttle Mir mission 4 (STS-79) August 1996	This experiment will test new super-conducting materials in space.

ACCOMPLISHMENTS AND PLANS

In FY 1994, the orbiter experiments (OEX) program was completed with the successful flight of the Orbiter Acceleration Research Experiment (OARE) accelerometer aboard STS-58. The data collected over the years by the twelve OEX experiments have been an important source for defining, designing and developing performance improvements in the present orbiter program and have supplied data for validating models for the design of future space transportation vehicles. The OARE was validated to an accuracy of 10^{-9}g and is the most sensitive three-dimensional accelerometer ever flown aboard the shuttle. This validated hardware will be utilized in future Life & Microgravity Sciences & Applications missions to accurately measure the microgravity environment.

Also in FY 1994, SPACEHAB-02 flew aboard STS-60. fully utilizing the leased lockers by carrying 10 commercial experiments. All experiments operated during the mission as required. Six IN-STEP experiments were successfully flown on a common hitchhiker carrier (OAST-2) aboard STS-62. These experiments investigated space environmental effects, providing the following results: (1) they showed that the release of nitrogen gas created a decrease in the intensity of spacecraft glow in the visible and far ultraviolet spectrums: (2) they enhanced the understanding of the interaction of high voltage surfaces in space: (3) they demonstrated the use of phase change material for thermal energy storage; and (4) they measured cosmic background radiation with the extreme accuracy needed to deduce its origins. Also on this mission, the re-flight of the Mid-deck 0-gravity Dynamics Experiment (MODE) was successful in predicting the dynamics of the truss structure and was able to capture all planned data. MODE is an university experiment and has contributed to 6 graduate studies and several undergraduate studies. In September 1994. the Lidar In-space Technology Experiment (LITE) successfully flew aboard STS-64 as a primary payload. This experiment was the first space-borne LIDAR to measure critical atmospheric parameters. LITE captured unprecedented atmospheric data that has been provided to the Office of Mission to Planet Earth's Earth Observation System (EOS) program for correlation with ground data. These measurements are expanding our knowledge of complex weather patterns (e.g. typhoons) and will enhance future weather predictions.

During FY 1994.51 out of 352 IN-STEP flight experiment proposals were selected from an open, competitive solicitation and began a nine-month Phase A feasibility study. Approximately 20 of these experiments will be selected in FY 1995 to continue into Phase B. The winning proposals include 109 participants from U.S. industries. universities, and government organizations located in 19 states. In addition, 5 "fasttrack" student experiments were selected from four different states. In FY 1994 and FY 1995, over 80% of the IN-STEP funding was provided to industry and universities both big and small. This demonstrates that open solicitation is an effectivetool for obtaining innovative concepts from a broad section of America. The flight of technology experiments will continue in FY 1995 including the flight of the Heat Pipe Performance experiment. Cryosystems experiments, and the Mid-deck Active Control Experiment.

In FY 1996, the IN-STEP program will continue the efforts begun in previous years leading to the flights of highly innovative and relevant experiments. The OAST Flyer mission will fly aboard STS-72 and obtain the first actual measurements of contamination due to the Return Flux Experiment (REFLEX). OAST Flyer will also demonstrate an innovative technology that will provide autonomous closed-loop control of spacecraft pointing through the use of Global Positioning Systems (GPS) signals. The Inflatable Antenna Experiment (IAE) Flyer mission will validate an inflatable technology that will provide a highly reliable antenna system offering a high order of magnitude reduction in the cost, mass. and stored volume of large (10 - 50 meters in diameter) antennas when compared to current systems. The Optical Properties Monitor (OPM) flight experiment (an international Space Station risk reduction effort) will be delivered for installation upon Mir and work will continue on the Hydrogen Maser Clock (HMC) experiment (another Mir experiment). The Vented Tank Resupply Experiment (VTRE) and the FY 1994 student experiments will be delivered for flight aboard various FY 1996 Shuttle missions. The next generation of approximately 20 new flight experiments that have successfully completed a Non-Advocate Review at the end of the definition phase will proceed into hardware design and development. These experiments address the needs of industry and NASA in the areas of: science sensors and sensor cooling; communications: vibration isolation; space power; in-space construction repair and maintenance: materlals: and cryogenic fluid handling.

The CMAM contract procures the services of 200 mid-deck locker volume equivalents (MLVEs) of space flight accommodations. After the third flight (SPACEHAB-03), which is scheduled to occur in March 1995 (STS-63), 142 of the 200 MLVEs will have been utilized. The fourth flight (SPACEHAB-04) is scheduled for April 1996 and the contract is scheduled for completion in the last quarter of FY 1996.

The Space Station Utilization line item was initiated in FY 1995. Eight payloads have been selected for Phase I Shuttle-Mir flights. These include four payloads involving industry/university/government partnerships accomplished through the Centers for the Commercial Development of Space. The four CCDS payloads are: the Commercial Generic Bioprocessing Apparatus (CGBA) and the Korund Liquid Phase Sintering metallurgy research, both to be launched on STS-76 in March 1996; and the Materials in Devices as Superconductors and Commercial Protein Crystal Growth projects, both to be flown on STS-79 in August 1996. Another of the Phase I payloads. the Energy Module, is sponsored jointly by two NASA offices (the Space Station Program Office and the Office of Space Access and Technology) and the Russian Space Agency. Flight of the Energy Module is scheduled for September 1997. The remaining three Phase I payloads are OSAT-funded technology/risk mitigation experiments which are manifested on Shuttle-Mir flights in 1995-1997.

For the Phase II/III Space Station Utilization program, FY 95 activities include updating the traffic model and payload candidate lists, and establishing the payload selection process. In addition, the OSAT is working closely with other user organizations to develop common equipment and facilities where appropriate and to establish programmatic mechanisms that will ensure optimum use of NASA resources. Unique payload accommodation requirements for the Space Station are also being developed and coordinated with the Space Station Program Office and other users. The Research Management Office at JSC is being utilized to analyze and integrate the user community requirements for the Space Station Program Office. In FY 1996, the Phase II/III selection process will have been established and initial payloads will be selected for Space Station Missions. Development schedules for these payloads will be based on the availability of user accommodations on the Station. Coordination with other users and with the Space Station Program Office on both common and OSAT-unique requirements will also continue.

BASIS OF FY 1996 FUNDING REQUIREMENT

COMMERCIAL TECHNOLOGY PROGRAMS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Technology dissemination and marketing.	9,000	11.700	10,000
Commercial applications. business practices, and metrics	12,900	21,600	17,800
(RTTCs)	[7,000]	[7,000]	[7,000]
Civil systems	5,900	12,500	12,600
(AdaNET)	[2,100]	[2,200]	[2,300]
(NTTC)	[3,400]	[9,800]	[9,800]
To	27.800	45,800	40.400

PROGRAM GOALS

NASA's goal is to elevate the commercial technology mission to a fundamental NASA mission, as important as any in the agency. by reinventing the way that the agency imparts the benefits of its knowledge, capabilities and research efforts into the national economy and the way that NASA derives benefits from the technological strength of American industry.

STRATEGY FOR ACHIEVING GOALS

NASA is in the process of implementing a new way of doing business in the area of technology transfer. Changes in National R&D investment guidelines have elevated the commercial technology mission to a fundamental NASA mission. NASA's Agenda for Change, approved by Administrator Goldin in July 1994, is the agency's blueprint for achieving this mission. The Agenda for Change is organized into six sections, each reflecting an important aspect of this new way of doing business. The six sections are: Commercial Technology Policy: Commercial Technology Business Practices: Marketing NASA's Capabilities: Commercial Technology Metrics: Culture Change Through Training and Education; and the Commercial Technology Electronic Network. Each section implements components of the national and agency policies in order to reinvent the way that NASA transfers technology to and from the national economy.

Two elements of the Agenda are particularly important if the overall goal is to be reached. The first element involves the creation of metrics which will allow program managers to determine the success rate of the various strategies. The other element is the creation of a new information network for commercial technology transfer. This network, to be fully operational by September 1996. will include 100% of current, non-sensitive technology activities and opportunities.

In addition, if it is to succeed, the commercial technology mission must become a responsibility of every NASA employee, contractor and grantee. The Agenda for Change marks the beginning of NASA's new focus, management commitment, and employee empowerment to improve our contributions to America's economic security through the pursuit of our aeronautics and space missions. All NASA program offices and field centers will invest appropriately to achieve the above goals, and NASA has adopted a near-term target of investing 10 percent of the agency's R&D budget in commercial partnerships with industry by the end of FY 1996. It is also anticipated that the field center offices will need to invest additional personnel to implement the new technology transfer practices consistent with the National Performance Review (NPR) goal of increasing field center flexibility to invest in technology transfer opportunities.

N OF PERFORMANCE

Complete development of performance metrics September 1995	Performance metrics will allow the program managers to determine the effectiveness of various commercialization methodologies and provide data for possible "mid-course corrections" to achieve greater program efficiencies from those areas requiring corrective action.
Inventory 100% of NASA technologies September 1996	*An* inventory of all NASA technologies is necessary to keep all partners in the technology transfer process knowledgeable about the available NASA technologies and to facilitate transfer of information.
Implement a detailed general and targeted marketing strategy October 1995	Marketing NASA technology and capabilities to industry is critical to NASA's ability to form partnerships with the private sector. A general and targeted marketing campaign will make it possible to understand industry's R&D requirements and identify where the synergies of NASA and industry technology partnerships can be most beneficial.
Implement technology commercialization business practice of investing 10% of NASA's R&D budget in commercial partnerships with industry by FY 1996. September 1996	Implementation of these practices is necessary to meet the National Performance Review goal of conducting NASA's technology development in partnership with industry to strengthen U.S. economic competitiveness.
Provide Internet-based access to the NASA commercial technology database September 1996	Use of the Internet will allow easier access by the public to NASA information.

ACCOMPLISHMENTS AND PLANS

In FY 1994, NASA initiated the Agenda for Change philosophy for implementing NASA's commercial mission. In FY 1995, efforts will be geared to accomplishment of the above goals based upon teamwork between the Office of Space Access and Technology and the other NASA program officesand each NASA field center.

- In FY 1995. initial steps have been taken to improve and strengthen the way NASA commercializes its technology. These steps include: the reorganization of field center technology commercialization offices to maximize the completion of commercial transfer and licensing agreements: increased involvement by the other NASA program offices and field center personnel in the transfer planning and coordination process: and the active cultivation and implementation of innovative technology transfer ideas at all levels. In addition, comprehensive commercialization performance metrics are being developed in FY 1995 which will provide managers with the performance information necessary to determine whether each aspect of the commercialization program is meeting predetermined measures of success. If performance in any area is marginal, a continual review of metrics data and examination of trends will provide early warning that program adjustments are necessary to improve performance to satisfactory levels. The NASA Commercial Technology Management Team (which involves the other NASA program offices and serves as NASA's technology transfer "board of directors") will continue to meet in an effort to ensure that the Agenda for Change is implemented successfully throughout the agency.

In FY 1996. NASA will continue to implement all aspects of the Agenda for Change. Particular focus will be placed on achieving the goal of investing 10 percent of the NASA R&D budget in commercial partnerships with industry. Based on experience to date, these commercial partnerships are expected to increase the return on the government's R&D investment, allowing NASA to do more with limited funds, as well as strengthening the international competitiveness of key industry sectors. Another key activity in FY 1996 will be the continued development and implementation of an Internet-based electronic network (E-NET) to integrate and support NASA's technology commercialization operations throughout the U.S. The E-NET will provide U.S. industry and research organizations with electronic access to information and databases which highlight available NASA technologies, technical expertise and facilities. The E-NET will serve as an electronic marketplace for these NASA assets, facilitating technology transfer and commercialization opportunities between U.S. industry and NASA. FY 1996 plans also include the creation of an automated, on-line, metrics collection system and technology transfer success story database for customer and stakeholder use.

BASIS OF FY 1996 FUNDING REQUIREMENT

LAUNCH VEHICLE SUPPORT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Launch services mission support	37,100	37,000	37,600

PROGRAM GOALS

NASA will provide the U.S. Civil Government payload community with successful, cost-effective. on-time, expendable launch vehicle (ELV) launch services.

STRATEGY FOR ACHIEVING GOALS

Through the Launch Services Mission Support budget, the Launch Vehicles Office (LVO): aggregates NASA and NOAA and international cooperative ELV mission requirements: establishes appropriate acquisition strategies for purchasing firm, fixed-price launch services from the U.S. industry to support the various performance classes of mission requirements: and imposes the scope and level of technical oversight of the commercial ELV operator's delivery of service that reflects the criticality of the mission and the level of government resources at risk. The objective is to provide affordable, 100%-successful delivery to space.

Since the reintroduction of a national mixed-fleet strategy in 1987, the LVO has delivered 100%-successful launch services (24 ELVs and 9 upper stages). The administration, procurement, and technical oversight of launch service delivery in the small and medium performance classes (Atlas-E. Titan II, Pegasus XL and Delta II, Ultra-Lite and Med-Lite) is managed by the Goddard Space Flight Center (GSFC). Launch services for the intermediate and large performance classes (Atlas I/IIAS and Titan IV/Centaur) are managed by the Lewis Research Center (LeRC). The Kennedy Space Center is delegated by GSFC and LeRC the responsibility for technical oversight of vehicle assembly and testing at the launch site and is responsible for launch site spacecraft processing. The Marshall Space Flight Center is responsible for management of Upper Stage missions. The NASA ELV 100% success record attests to the value of its technical oversight program.

The Launch Services Mission Support budget funds a variety of activities, including: technical oversight of the commercial ELV providers: payload and launch vehicle integration work maintenance of launch facilities, including telemetry laboratories, on both the east and west coasts: and the Secondary Payloads program, which allows university and international cooperative payloads of 50 kilograms or less to be flown for less than $2 million by utilizing excess capacity on scheduled ELV launches.

The LVO utilizes a variety of management techniques to ensure that the best possible launch services are provided at the lowest possible cost. NASA launch services contracts are firm, fixed-price, for delivery on-orbit with reciprocal liquidated damages for late

delivery and incentives for success. NASA fixed-price contracts have limited launch costs growth to no more than 5% due to mission unique requirements and spacecraft delays.

In addition to using fixed-price contracts, the LVO also controls costs by maintaining launch delay data bases, which identify spacecraft-vs. vehicle- vs. range-caused delays in order to minimize/avoid NASA launch delay penalties. By maintaining an accurate database, the LVO can anticipate delays and can avoid making manifest changes just prior to launch, when penalties are generally much higher. Moreover, with the database, the LVO can ensure that the agency is not charged for delays beyond its control. The LVO also tracks launch services prices throughout the industry to ensure that the prices paid by NASA are comparable to those paid by the DoD and commercial communications satellite community.

As part of the effort to improve its performance. the LVO conducts an annual customer survey to solicit feedback from customers regarding ways to enhance customer service.

MEASURES OF PERFORMANCE

The key measure of performance is the successful delivery of the mission into the specified orbit at the time the spacecraft is ready for launch. The LVO is working to maintain its 100% success standard. The following launches are currently planned to be supported through FY 1999:

FY 1995	4 Small ELVs 3 Medium ELVs 1 Intermediate ELV 1 Upper Stage
FY 1996	2 Medium ELVs
FY 1997	2 Ultra-Lite ELVs 3 Medium ELVs
FY 1998	1 Small ELV 1 Medium ELV 1 Intermediate ELV 1 Large ELV 1 Upper Stage
FY 1999	3 Small ELVs 4 Med-Lite ELVs 1 Intermediate ELV

Other critical milestone metrics include:

Release of Med-Lite RFP December 1994	Med-Lite enables NASA to provide low-cost launch services in support of recently downsized NASA spacecraft.
Ultra-Lite contract award December 1994	Ultra-Lite enables NASA to provide low-cost launch services in support of recently downsized NASA spacecraft.
Med-Lite proposals due February 1995	NASA is seeking ways to expedite the evaluation of these proposals.
Intermediate ELV contract final Award May 1995	Supports delivery of EOS-AM spacecraft payload adaptor to meet June 1998 launch date. The IELV contract will provide pre-priced, fixed-price launch service funding profiles for all future intermediate-class missions through 2005.
Med-Lite contract award August 1995	NASA is seeking to expedite the proposal evaluation process and advance the date of this milestone.

A ISHMENTS AND PLANS

In FY 1994. the Intermediate ELV (IELV) and Ultra-Lite ELV (UELV) launch services contractors were selected. The Scout program was concluded and residual flight assets/launch facility were transitioned to USAF. Modification of launch pad SLC-2W at Vandenberg Air Force Base was completed, enabling the launch of NASA. DoD and commercial payloads from the west coast on Delta II vehicles. Design and development of the Pegasus dual-payload adapter was finished. allowing launch of NASA, DoD and commercial payloads on Pegasus. In addition, three tethered payloads were successfully launched into space as secondaries aboard the Delta 11

In FY 1995 the plan is to provide on-time, successful launch of the following spacecraft manifested for launch: TOMS/MTPE, FAST/OSS, dual launch of HETE/OSS and SAC-B (Argentine) cooperative. SWAS/OSS, Radarsat/Canadian cooperative, XTE/OSS, SOHO/ESA cooperative, TDRS-G/OSC (Upperstage on STS), and a secondary payload: SURFSAT. Also planned is the award of the IELV. UELV and Med-Lite contracts.

In FY 1996 the plan is to provide on-time, successful launch of the following spacecraft manifested for launch Polar/OSS in December 1995, NEAR/OSS in February 1996; and two secondary payloads on the USAF ARGOS launch in January 1995. These secondaries represent launch of the first Danish spacecraft (Orsted) and launch of the first South African spacecraft (Sunsat).

BASIS OF FY 1996 FUNDING REQUIREMENT

SMALL BUSINESS INNOVATION RESEARCH PROGRAMS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Small business innovation research (SBIR) awards	[107,3001	118.000	120,100
Small business technology transfer (STTR) pilot program awards	(3,600)	5,900	9,000
To.....	[110,900]	123,900	129.100

PROGRAM GOALS

The goal of NASA's Small Business programs is to promote the widest possible award of NASA research contracts within the small business community and facilitate commercialization of these research results by the small business community.

STRATEGY FOR ACHIEVING GOALS

Established by Congress, the Small Business Innovation Research (SBIR) program helps NASA develop innovative technologies by providing competitive research contracts to US owned small businesses. The program is structured in three phases:

Phase I is the opportunity to establish the feasibility. technical merit and desirability of a proposed innovation. Selected competitively, Phase I contracts last for six months and currently do not exceed $70,000.

Phase 11 is the major R&D effort in SBIR. The most promising Phase I projects are selected to receive contracts worth up to $600.000 and lasting up to two years. In general. about 50 percent of Phase I projects are approved for Phase II.

Phase III is the completion of the development of a product or process to make it marketable. The financial resources cannot come from SBIR funds. Private sector investment in various forms is the usual source of Phase 111 funding.

The NASA SBIR solicitation has 15 major topic areas. which *are* divided into sub-topics. The description of each of these sub-topics is developed by various NASA installations to include current and foreseen agency program needs and priorities. NASA typically receives 2300 or more individual proposals each year. Proposals are evaluated by the NASA field centers for scientific and technical merit; key staff qualifications; soundness of the work plan: and anticipated commercial benefits. NASA HQ program offices provide additional insight into commercial applications, program balance, and critical agency requirements. Selections are

made by NASA HQ based upon these recommendation and other considerations. Typically about 400 Phase I awards are selected each year.

In addition to an extensive on-line database regarding the program, NASA also provides information for public access via a bulletin board service and Internet servers. Moreover, NASA has begun to use information technology for the process of developing the technical sub-topics in the solicitation, for the public release of the solicitation in electronic formats and for proposal evaluation.

The NASA Small Business Technology Transfer Pilot program (STTR) is a three-year program established in 1994. In STTR, small businesses and research institutions with technological and business expertise submit joint proposals to convert intellectual property resident in the research institution into products that meet a NASA need and have commercial potential. The STTR program, though modeled after the SBIR program, is a separate activity with separate funding and important differences in scope relative to SBIR The STTR program objective is to stimulate and foster scientific and technological innovation, including increasing commercialization of Federal R&D. The STTR program is structured in the following three phases:

Phase I involves a solicitation of proposals to conduct experimental or theoretical research into the feasibility of technologies intended to meet described agency requirements. The object of this phase is to utilize a relatively small agency investment to determine the scientific, technical and commercial merit and feasibility of the proposed cooperative effort, as well as the quality of performance of the small business concern, before consideration of further Federal support in Phase II.

Phase 11 continues the R&D effort from Phase I toward a commercial outcome. Only awardees in Phase I are eligible to participate in Phase II. Funding of Phase II proposals is based on the results of Phase I, as well as the scientific and technical merit and the commercial potential of the Phase 11 proposal.

Phase III continues the R&D effort with non-STTR funding. Phase 111 objectives are pursuit by STTR contractors of commercial applications of their project results, using private sector funds, and/or further (non-STTR) contracts with the government relative to the STTR project.

Although selected from different criteria than those of SBIR, the *SITR* program uses the same basic processes to determine requirements and select awardees. The processes also utilize the same new information technologies as the SBIR program, and adds to them the ability to submit proposals in an electronic format. As a result, NASA's paperless, electronic system will enable the electronic distribution of solicitations to the business community, the electronic submission of proposals from the business community, the provision of these proposals to evaluators electronically, and the receipt of review forms electronically. The new information handling technologies should speed up the award process substantially, while also reducing the amount of staffing that NASA must devote to the process.

The Agency will obtain commercialization metrics (revenue, jobs creation) from previous SBIR and STTR awardees in order to better measure the success or failure of the program to meet its commercialization objectives.

MEASURES OF PERFORMANCE

Select and announce new SBIR Phase I awards resulting from the FY 1994 solicitation October 1994	Meets the requirements of public law.
Select and announce new SBIR Phase 11 awards resulting from the FY 1994 solicitation November 1994	Meets the requirements of public law.
Complete development and issuance of the FY 1995 STTR solicitation January 1995	Necessary to ensure the success of the FY 1995 research program.
Complete development and issuance of the FY 1995 SBIR solicitation May 1995	Necessary to ensure the success of the FY 1996 research program.
Select and announce new STTR Phase I awards resulting from the FY 1995 solicitation July 1995	Meets the requirements of public law.
Implementation of Internet access to SBIR and STTR documents August 1995	Reduction of paper processing overhead costs and time needed to award contracts.
Select and announce new SBIR Phase I awards resulting from the FY 1995 solicitation October 1995	Meets the requirements of public law.

Select and announce new SBIR and STTR Phase II awards resulting from the FY 1995 solicitation November 1995	Meets the requirements of public law.
Complete development and issuance of the FY 1996 STTR solicitation January 1996	Necessary to ensure the success of the FY 1996 research program.
Compilation of commercialization metrics from 60% of previous Phase II awardees February 1996	Will improve knowledge of the success of the program in actually commercializing technology.
Complete development and issuance of the FY 1996 SBIR solicitation May 1996	Necessary to ensure the success of the FY 1997 research program.
Select and announce new STTR Phase I awards resulting from the FY 1996 solicitation July 1996	Meets the requirements of public law.

ACCOMPLISHMENTS AND PLANS

The NASA SBIR program has contributed to the US economy by fostering the establishment and growth of some 975 small, high-technology businesses. Twenty major participants have produced more than $150 million in new revenues.

In FY 1994, 383 new SBIR Phase I awards and 174 new Phase II awards were made. The SBIR solicitation was made available electronically on Internet for the first time. In 1994, its initial year, the STTR program solicitation addressed three specified NASA program needs. The STTR solicitation received responses from 151 firms, and 21 Phase I STTR awards were initiated.

In FY 1995, another 412 new SBIR Phase I awards and 190 new Phase II awards were made. The 1995 STTR solicitation addresses an even greater technology base through its expansion from three to five topic areas. Approximately 30 new STTR Phase I awards

and 10 new Phase I awards are planned for FY 1995. NASA also plans to continue increasing the utilization of electronic methods to disseminate and receive information in FY 1995.

By the end of FY 1996, plans are to complete the creation of a paperless electronic process for SBIR and STTR and to obtain increased commercialization metrics from SBIR and STTR awardees in order to be able to more adequately measure progress in commercializing technology. SBIR awards are anticipated to be made in approximately the same quantities as in FY 1995. FY 1996 is the last year of the three-year STTR pilot project; therefore, the focus will be on Phase II awards.

Mission
Communication
Services

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

MISSION COMMUNICATION SERVICES

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995	FY 1996	page Number
		(Thousands of Dollars)		
Ground network	309.300	273,400	268,800	SAT 6-4
Mission control and data systems	206,481	175,800	162,200	SAT 6-10
Space network customer service	30,000	32,000	30,300	SAT 6-19
Advanced systems	19,600	--	--	
Construction of facilities	15,600	--	--	
To	580.981	481.200	461,300	
Distribution of Program Amount by Installation				
Johnson Space Center	50	--	--	
Marshall Space Flight Center	2,500	3.000	3,000	
Ames Research Center	14,300	16,600	13,900	
Lewis Research Center	1.397	1,800	1,900	
Goddard Space Flight Center	322.113	260,400	240,700	
Jet Propulsion Laboratory	215,159	176,700	178,300	
Headquarters (including foreign contracts)	25.462	22.700	23,500	
To	580.981	481.200	461.300	

OFFICE OF SPACE COMMUNICATIONS **MISSION COMMUNICATION SERVICES**

PROGRAM S

To enable the conduct of the NASA strategic enterprises by providing telecommunications systems and services. Reliable electronic communications are essential to the success of every NASA flight mission, from interplanetary spacecraft to the Space Shuttle to aeronautical flight tests.

NASA's Office of Space Communications (OSC) manages the provision of telecommunication services needed to ensure that the goals of NASA's exploration. science, and research and development programs are met: that they are met cost-effectively: and that mission operations and planning are performed in an integrated and standardized way. The OSC is committed to seeking and encouraging commercialization of NASA telecommunications capabilities and to participate with NASA's strategic enterprises in collaborative interagency. international, and commercial enterprises. As NASA's agent for operational communications and associated information handling services, the OSC seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests.

ATEGY FOR ACHIEVING GOALS

The range of capabilities provided by NASA's Space Communications program is necessarily very broad. This function provides all of NASA's capability to track, command, and acquire data from NASA spacecraft. This function is performed through utilization of ground-based antennas and network systems: the Tracking and Data Relay Satellite System (TDRSS) of geosynchronous communications satellites and its Earth-bound ground stations: a telecommunications network needed to relay data among NASA mission control facilities: and the mission control and data processing facilities for NASA's currently operational Earth-orbiting robotics systems. The function also provides for the telecommunications network used for all NASA administrative and scientific exchanges. All NASA telecommunications scheduling, network management and engineering, flight system maneuver planning and analysis. and preflight communications interface verification is performed by this strategic function. Near-term demonstration and application of advanced communications and information systems technologies are conducted through the support of various sponsored labs and facilities.

Some NASA missions have unique needs -- e.g., communicating with spacecraft having low-powered transceivers flying in the outer reaches of our solar system and beyond or relaying very high rates of data from spacecraft anywhere over the roughly 785 million square miles of surface area of the Earth. Specialized systems such as the Tracking and Data Relay Satellite System (TDRSS) and the Deep Space Network (DSN) are required. Other needs can be satisfied using alternate approaches, including

smaller ground transceive systems and commercially-available systems and services. Key to NASA's future is our ability to take advantage of emerging communications technologies, especially the increasing levels of automation and standardization of systems and procedures that these technologies allow.

Integrated solutions to Agency communication and information management needs are sought based on understanding and accommodating common aspects of all of NASA's programs. Cost-effective systems are achieved through an integrated. end-to-end approach to the design of communication systems, including the large and costly data processing systems needed to support current and future NASA missions. NASA flight programs are supported through study and coordination of the data standards and communications frequencies to be used in the future.

The Space Communications function is carried out collaboratively with other NASA programs in the formulation of NASA's policy interests. When science or exploration goals require coordination of international or other U.S. telecommunications, mission control or data processing capabilities, NASA's space communication assets are incorporated into agreements and understandings. International and interagency agreements are entered into for the exchange of communication services among space-faring nations, other U.S. agencies, and in support of commercial U.S. space enterprises.

The Mission Communication Services program. one part of NASA's Space Communications program, provides support to the breadth of NASA missions, including planetary and interplanetary missions: Human Space Flight missions: near-Earth and Earth-orbiting spacecraft missions: suborbital and aeronautical test flight systems. Services include tracking, orbit and attitude determination, maneuver analysis, communications scheduling, spacecraft command. spacecraft health and safety data acquisition, and science data acquisition. Mission control and science data processing for select NASA missions: communications technology initiatives: coordination of flight mission planning: and management and coordination of NASA's use of radio frequencies is also conducted under this program.

The facilities and systems of NASA's Deep Space Network Wallops Orbital Tracking Station: Space Network Control Center: and the Mission Control and Data Systems program are in the process of being automated and modernized so that the burgeoning workload of NASA flight systems can be accommodated within the decreased funding levels assigned to this NASA strategic function.

BASIS OF FY 1996 FUNDING REQUIREMENT

GROUND NETWORK

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Deep space network systems implementations	98,324	103,800	107,000
Deep space network operations	100,371	88.200	85,200
Spaceflight tracking and data network systems implementation..	3,400	9.200	8.500
Spaceflight tracking and data network operations	55,055	29.000	25,300
Aeronautics, balloons, and sounding rockets systems implementation	27,250	16.800	17,700
Aeronautics, balloons, and sounding rockets operations	24.900	26,400	25,100
Total	309,300	273,400	268,800

PROGRAM GOALS

To provide reliable. cost-effective ground-based tracking, command and data acquisition systems and services for NASA science and aeronautics programs. These missions include planetary, interplanetary, near-Earth and Earth-orbiting science missions: aeronautical test flights: and suborbital balloon and sounding rocket flights. Launch, emergency communications. and landing support for the Space Transportation System (STS) is also provided by Ground Network facilities. Advanced Technology initiatives for NASA's Ground Network are also supported. The Ground Network program provides for the implementation. maintenance and operation of the tracking and communication facilities necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems.

The Ground Network program supports NASA's programs in collaborative interagency, international. and commercial enterprises, and independently provides support to other national, international. and commercial space-faring enterprises on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

NASA's Ground Network is comprised of the Deep Space Network (DSN), managed by the Jet Propulsion Laboratory (JPL); the Space Flight Tracking and Data Network (STDN), managed by the Goddard Space Flight Center (GSFC): the tracking and data acquisition facilities of the Aeronautics, Balloon and Sounding Rocket (AB&SR) program, managed by GSFCs Wallops Flight Facility (WFF); and the Western Aeronautical Test Range (WATR). The WATR is also funded under the AB&SR program and

managed by the Dryden Flight Research Center (DFRC). The AlliedSignal Technical Services and Computer Science Corporations are the primary support service contractors responsible for ongoing implementation and operation of these ground networks.

The operational facilities of the Ground Network enable tracking. command and data acquisition of space flight systems. The Ground Network is the primary telecommunications interface for planetary and deep space missions: for suborbital and aeronautical test programs: for small and medium-class Earth-orbiting spacecraft with limited capacity for high data rate communications: and, increasingly, for high data rate, polar-orbiting systems. Support for launch, tracking, backup and emergency access, and landing of the STS is also provided as is emergency access to all other NASA Earth-orbiting spacecraft; those same facilities are used to support expendable launch vehicle (ELV) deployments of NASA. other U.S. agency, international, and commercial enterprises. All of the science disciplines that NASA supports are either directly or indirectly supported by NASA's Ground Network.

The DSN, managed by the JPL, Pasadena, California provides telecommunications for NASA's planetary and solar system exploration missions and Earth-orbiting missions that operate outside the capability of other NASA communication systems. The DSN receives spacecraft telemetry and download of scientific data and transmits command, control and navigation signals to a variety of spacecraft from distances relatively near the Earth to those as great as 8 billion kilometers from the Earth. Three DSN antenna and communications support complexes are maintained at Goldstone, California: Canberra, Australia: and Madrid, Spain. The central Network Operations Control Center (NOCC) is located at the JPL in Pasadena. California.

The systems required to perform tracking and data acquisition of spacecraft at the limits of the solar system are highly specialized and include large aperture antennas which can receive extremely weak radio signals. These antennas use ultra-sensitive receivers and powerful transmitters. Extremely stable time standards are also required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the NOCC located at the JPL and the deep space communication complexes located in California. Spain, and Australia. The DSN also supports collaborative ground-based radar and radio astronomy observations. The network's ultra-sensitive antennas are used to study pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena. Radar studies of the surface characteristics of planets, planetary rings, asteroids, comets, moons, and near-Earth asteroids are also supported.

The STDN consists of two ground stations at Bermuda and Merritt Island, Florida. These stations provide pre-launch payload support and system verification testing, launch. and landing communication for the STS; and payload verification. launch support, and range safety functions, in coordination with the WFF. for other U.S. and commercial launch activities on the Eastern Range.

The STDN ground communication stations provide primary operational support during the launch and landing phases of STS missions: backup and emergency support for STS while on-orbit is also provided by the DSN and WFF. Emergency access to scientific spacecraft supported by the Tracking and Data Relay Satellite System (TDRSS), and to the TDRS spacecraft themselves, is also provided by DSN and STDN systems. Command destruct capabilities for the STS and ELVs are maintained at the WFF and Bermuda STDN sites.

The AB&SR system of facilities and services is used to conduct a very diverse range of activities, in support of NASA, other U.S., international and commercial space and aeronautics initiatives. Tracking, radar, telemetry, data acquisition, data processing, data display, communications, and special purpose optical equipment are provided for the various uses supported by the facilities of the AB&SR system.

The WFF, located at Wallops Island, Virginia supports tracking, command and data acquisition for scientific and meteorological spacecraft and sounding rockets: the STS; small meteorological balloons: and for NASA and commercial launch vehicle deployments. The WFF also provides tracking and communication support for aeronautics flight programs in the areas of automatic landing operations using Global Positioning System (GPS) inputs: aircraft wake studies: the Shuttle Microwave Scanning Beam landing system: range surveillance: and Langley drop model testing. The WFF provides a wide range of reimbursable services, primarily for the Department of Defense (DoD). These include tactical systems of the Department of the Navy: meteorological systems of the Department of the *Army:* landing operations for Dover Air Force Base and launch support for the Department of the Air Force's Eastern Range: and support for experiments of the Ballistic Missile Defense Organization (BMDO).

The WFF also manages several off-site facilities at the White Sands Missile Range, New Mexico: the Poker Flat Research Range, Fairbanks, Alaska; the National Scientific Balloon Facility, Palestine. Texas and Ft. Sumner, New Mexico. Mobile tracking and data acquisition systems are also used to support remote balloon and sounding rocket launches, and a growing number of small spacecraft systems. These systems include the Transportable Orbital Tracking System (TOTS). Two TOTS are maintained at NASA's Poker Flat facility for primary support of the NASA's Fast Auroral Snapshot Explorer (FAST), Submillimeter Wave Astronomy Satellite (SWAS), future Small Explorer missions. and launch of Total Ozone Mapping System-Earth Probe (TOMS-EP) and several international deployments. A third TOTS is currently deployed at Andoya. Norway for sounding rocket studies of Earth's aurora.

Additionally, the WFF provides the administrative, technical, and operational support needed to establish new ground communication facilities in Earth's polar regions for future missions related to the international Earth observing program. Through a series of interagency and international agreements and collaborations, NASA's Ground Network program is providing an increasing level of tracking, command, and data acquisition support for NASA, other U.S.. and international flight systems dedicated to international and U.S. studies of global change. In cooperation with other U.S. agencies, facilities at McMurdo Sound. Antarctica and at Fairbanks. Alaska, are being developed as the principal ground stations for the joint U.S.-Canada RadarSat mission and the international Advanced Earth Observing System (ADEOS) mission, respectively. The Fairbanks, Alaska site serves as the principal U.S. ground communication facility for the international Earth Remote Sensing Satellite (ERS) and Japanese Earth Remote Sensing Satellite (JERS) synthetic aperture radar missions.

The WATR, which has conducted operations for 35 years, provides tracking and communication systems and services for aeronautical research flight testing at the DFRC, Moffett Field and Crows Landing. Tracking and communication services for STS landings are also provided in cooperation with DSN facilities at Goldstone. Tests of high performance aircraft, advanced technology research aircraft, and complex control systems and powered lift technologies are conducted through the support of these facilities.

Early development of advanced technologies and operational approaches for deep space and Earth-orbiting systems is conducted by NASA's Ground Network program. These initiatives support the need to provide tracking. navigation, command and data acquisition functions in a way that economizes NASA's total investment in new space flight and telecommunications support systems. The continued emergence of small, less expensive, but often more capable NASA flight systems makes it necessary to find new, inexpensive but reliable telecommunications systems and services for support of these missions. For example, the JPL will develop Ka-band command and receive systems that will support miniature spacecraft systems and other low-cost approaches for deep space exploration. Other JPL investments in autonomous ground tracking stations for Earth-orbiting systems: atmospheric calibration techniques: highly stable frequency standards: commercial low-noise amplifiers: a new low-cost, low-power deep space transponder: and high data rate. optical communication systems promise to enable a new generation of low-cost, highly capable space flight systems.

Another cost-saving program is to demonstrate the potential uses of the GPS for NASA flight systems. in conjunction with NASA's Small Satellite Technology Initiative (SSTI) and the STS programs. If successful, these demonstrations would allow NASA to replace expensive ground tracking subsystems and lower future operations expense. Following demonstration of GPS technology for STS deployments, further reduction of STDN capabilities will be evaluated.

Both the number of missions served by NASA's Ground Network facilities and the unique requirements of those missions are expected to increase dramatically over the next several years. The Ground Network program will continue to implement reliability and maintainability initiatives to ensure that necessary planning and operational support is provided to NASA flight programs and to decrease the operational cost of NASA telecommunications. Reengineering efforts now in process are expected to reduce the cost of operating the DSN by approximately 30% while supporting NASA's increased flight rate. These initiatives include upgrade of the DSN monitor control system and compatibility test systems, and a new digital receiver. Similarly. upgrades of the WFF and the WATR are expected to reduce operating costs while also providing the opportunity for additional utilization of these highly cost-effective facilities. The WFF upgrade will replace two obsolete antenna systems with new 11 meter antennas. and replace labor-intensive support systems with automated equipment. The improvements will result in higher data capacity X-band services in coordination with NASA's Earth science programs. The WATR upgrade will consolidate the operation of radar and other ground communication systems while also providing for faster, higher resolution display of aeronautical flight system data. This project is expected to result in improved services to NASA's flight test program.

In addition to the pursuit of cost-saving measures. NASA is also in the process of upgrading its ground network systems to accommodate future missions. NASA's Ground Network program seeks to ensure that integrated. cost-effective solutions for accomplishing the goals of NASA's programs are supported and the advanced mission requirements of NASA space flight systems are accommodated by NASA ground systems. The "capability" and "capacity" of the network systems is continuously subject to changes as NASA's flight system goals become more challenging, economical, and numerous. The expansion of ground network facilities in Antarctica and Alaska, as discussed above, fulfills the need to provide innovative solutions for the emerging demands of new polar-orbiting, Earth observing flight systems. Increased on-orbit data storage capacity of emerging spacecraft designs allows for more economical data acquisition approaches to be pursued. Use of ground network facilities to support NASA's Earth Observing System (EOS) series of spacecraft beyond AM-1 is currently being reviewed.

Similar upgrades of the DSN are ongoing. The DSN is the world's premier facility for tracking deep space probes. This world-wide network can occasionally be supplemented by the facilities of other agencies or nations, but there is no other network that compares in coverage and sensitivity to the DSN. Several development initiatives are underway to improve the capacity and quality of DSN services, including the installation and upgrade of several new antennas. New 34 meter Beam Wave Guide (BWG) antennas are being installed at the DSN complexes to handle the projected number of deep space missions and provide for future capability upgrades. These antennas are also expected to reduce the operations complexity and cost of the DSN system. Once in place, these new DSN antennas will allow three obsolete antennas to be phased out and better enable NASA to provide continuous and more efficient support to its growing list of deep space and planetary missions.

Other DSN systems modifications include a new convolutional decoder for the Cassini mission, which will provide a significant improvement in science data return. NASA is also modifying its 70 meter DSN antennas to support high power, X-band commanding of Cassini. Finally, a specialized Ka-band radio science capability needed for experiments related to the density and composition of Saturn's atmosphere is being developed by NASA's Ground Network program. The latter capability will also support gravity wave experiments.

The Galileo mission, currently enroute to Jupiter, required special enhancement of data compression, modulation and antenna arraying capabilities of the DSN due to the inability to use the spacecraft's high gain antenna as planned. NASA will also modify the Australian Parkes Radio Astronomy Observatory to augment the return of data from Galileo. Modification of the antennas mechanical assembly will allow for shared use for Galileo and cumnt radio astronomy users.

Another mission-specific implementation is the Orbiting Very Long Baseline Interferometry (OVLBI) program. This joint NASA-National Science Foundation and international program is to add spacecraft systems to Earth's existing radio astronomy facilities to achieve unprecedented levels of accuracy and sensitivity in this domain of highly precise astrophysical measures. The Japanese VLBI Space Operation Program (VSOP) and the Russian Radioastron missions, scheduled for launch in 1996 and 1997 respectively. are to provide for much higher resolution radio-astronomy than is currently possible using only ground systems.

The Ground Network program also supports the Apple Valley Science and Technology Center, a private science and education organization located in Apple Valley, California. to encourage young people to become interested in Radio Astronomy and space communications. Under this project, students will be allowed access to an obsolete DSN antenna to conduct radio astronomy experiments.

MEASURES OF PERFORMANCE

	FY 1994	FY 1995	FY 1996
Deep Space Network			
Number of NASA missions supported	39	45	46
Number of hours of service	63,000	64,000	70,000

Mission support provided by the DSN is composed of a wide range of services. For example, in FY 1994 the DSN provided telecommunications services for 10 deep space missions: 10 Earth-orbiting missions for which the DSN provided primary operational support: 7 flights of the STS; and 12 Earth-orbiting missions for which the DSN provided emergency support, including the TDRS constellation.

	FY 1994	FY 1995	FY 1996
Spaceflight Tracking and Data Network			
Number of STS deployments supported	7	7	7
Number of ELV deployments supported	11	13	12

The STDN is reauired to be available during the launch countdown sequence so as not to cause a launch hold condition and to provide at least 99% of the Space Shuttle data to the Mission Control Center at Johnson Space Center during the Shuttle launch phase, a standard that was met consistently in FY 1994. This standard of performance will be maintained.

Wallops Flight Facility			
Number of NASA Earth-orbiting missions supported	21	25	26
Number of Sounding Rocket deployments supported	33	40	40
Number of Balloon deployments supported	22	29	29
Number of hours of service (Wallops Orbital Tracking Station only)	27,227	32,000	31.000

Mission support provided by the WFF is also composed of a wide range of services. including support to the STS and to high data rate synthetic aperture radar systems. The WFF also supported 52 meteorological sounding rocket deployments: 253 NASA and DoD small meteorological balloon deployments: 31 deployments of DoD drones, missiles, and rockets: and 90 NASA and 193 DoD aeronautical tracking events in FY 1994.

Western Aeronautical Test Range			
Number of NASA missions supported	1077	1100	1100
Number of NASA research flights supported	494	500	500

ACCOMPLISHMENTS AND PLANS

In FY 1994, the DSN provided primary operational support to the deep space Ulysses, Voyager 1 and 2. Pioneer 10 and 11. Clementine and International Cometary Explorer (ICE) missions: the Magellan and Galileo planetary missions: the international ASCA, YOHKOH, Roentgen Satellite (ROSAT), and Geotail missions: NASA's Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX), NIMBUS-7, and Earth Radiation Budget Satellite (ERBS): and seven flights of the STS. The launch of the first of the next generation of Geostationary Operational Environmental Satellites (GOES-I) was also supported in 1994: operational

support is provided on a contingency basis to this meteorological spacecraft series. Launch and operation of the joint U.S.-British Space Technology Research Vehicle (STRV), a year long demonstration of several advanced technologies, was also supported in FY 1994 and will continue through FY 1995. Emergency operational support is provided for spacecraft normally supported by NASA's TDRS System (TDRSS), including the TDRS. Hubble Space Telescope, Compton Gamma Ray Observatory (CGRO). and Upper Atmospheric Research Satellite (UARS) systems. Contingency support is also provided for the Landsat series of spacecraft. Reimbursable launch support was provided for the international Eutelsat II F-5 and ETS-VI missions in FY 1994.

Magellan operations ceased in FY 1994 after the spacecraft entered Venus' atmosphere. Mars Observer was lost during orbit insertion: the DSN search for Mars Observer continued for 3 months in FY 1994 prior to confirming the satellite's loss. NIMBUS-7 operations also ended in FY 1994. Primary operational support for the ROSAT, SAMPEX NIMBUS-7 and ERBS missions are shared among NASA's telecommunications networks.

Several new missions are to be deployed in FY 1995 through the support of the DSN. NASA's WIND spacecraft was launched in November 1994, to be followed by the TOMS-EP, SWAS. and the FAST missions. Launch of the international Infrared Space Observatory (ISO), Space Flyer Unit (SFU-1). and RadarSat missions is also to occur in FY 1995. The DSN will provide primary operational support for all of these missions: primary operations of the SWAS, FAST, TOMS-EP and RadarSat missions are also supported by WFF systems.

Launch of NASA's X-ray Timing Explorer (XTE), GOES-J. and the seventh TDRS spacecraft will also be supported by the DSN. Reimbursable support will be provided for deployment of the international Eutelsat II F-6, SFU-1, Geostationary Meteorological Satellite (GMS-5). Helios-1, and Telecom 2-C missions in FY 1995.

In FY 1996. NASA's Near Earth Asteroid Rendezvous (NEAR) and POLAR and the international Solar Observatory for Heliospheric Observation (SOHO). Cluster, and VSOP will be deployed and operated through the support of the DSN. Reimbursable support for the deployment of Telecom 2-D is to be provided. Launch preparations for the Mars Global Surveyor (MGS) and Mars Pathfinder missions, also to be operated by the DSN, will occur late in FY 1996 for deployment in CY 1996.

The first of the new 34 meter BWG antennas is to become operational at the Goldstone complex in FY 1995: a second and third antenna will follow in FY 1996 and FY 1997. An additional 34 meter BWG antenna at Canberra, Australia is scheduled to be operational in FY 1997. A fifth antenna has been added to the Ground Network program during the current funding cycle to resolve scheduling conflicts among several future planetary missions. This antenna is to be installed at Madrid, Spain and made operational by the time of Cassini deployment in November 1997. Upgrade of an experimental 34 meter antenna, transferred to NASA under agreement with the U.S. Department of the Army, will also proceed in FY 1995 and FY 1996. This antenna, located contiguously with the Goldstone complex, is a different design than DSN antennas and will require extensive modifications to support deep space operations. It will be used to track satellites in highly elliptical Earth orbits beginning in FY 1995. Ongoing sustainment activities will continue throughout this period, including efforts to extend the life of the DSN 70 meter antenna. Replacement of the DSN's S-band transmitters and masers will be initiated in FY 1996.

Emergency X-band uplink service for Cassini will begin to be developed in FY 1996. A prototype of Ka-band ground systems will be developed in FY 1995 and 1996, in preparation for development of an operational system in FY 1997. Work on convolutional decoders will continue throughout this period in preparation for Cassini deployment early in FY 1998. Changes to the DSN to accommodate communication with Galileo are to be completed in time for encounter with Callisto in FY 1997. Data compression systems and hardware procurement for DSN antenna arraying are complete. Installation of signal combining and recording systems required for arraying is underway. The modification of the Parkes antenna will be performed throughout the current period. Finally, two new 11 meter antennas will be added to the DSN sites at Goldstone and Canberra in FY 1995 and at Madrid in FY 1996, to support the international OVLBI program. A similar capability has been completed at Greenbank, West Virginia through restoration of a 14 meter antenna at the National Science Foundation (NSF) facility.

In FY 1994, the STDN was transitioned to only providing launch and landing support for deployments of the STS. Reduction of STDN operations began in FY 1994. Further transition of STDN support requirements are contingent on FY 1996 and FY 1997 demonstrations of GPS technology for STS position and attitude determination. A third STDN station at Dakar was closed in FY 1994. Ultra high frequency (UHF) voice communication with the STS will continue to be provided from a Senegalese government communication facility until December 1995, when all support from Senegal will be terminated. Termination is feasible at that time because of the completion of redundant Space Network ground terminal capability at the White Sands, New Mexico complex. The STDN will continue to provide launch support for ELVs when these can be accommodated by existing support systems. In FY 1994, the STDN supported the deployment of GOES-I and 2 GPS payloads and provided reimbursable support for deployment of Telstar, Milstar, DSCS, Galaxy, UHF. DoD, NATO, and DIRECTV payload systems. In FY 1995, deployment of WIND. XTE, SOHO. GOESJ will be supported. Reimbursable support for deployment of 3 Intelsat systems, ERS-2, Helios-1, Orion, Koreasat, EHF. DoD, and MSAT will be provided. Launch support for the NASA's NEAR mission will also be provided in FY 1996. Reimbursable support for 11 ELV deployments will be provided, including Koreasat, Telstar, DBS, JCSAT, 4 UHF, 2 Inmarsat. and Hotbird payloads.

In FY 1994. the WFF served as the primary ground station for NASA's International Ultraviolet Explorer (IUE), ERBS, SAMPEX, Cosmic Background Explorer (COBE) and NIMBUS-7 missions. WFF is also the primary U.S. ground station for the international Total Ozone Mapping System-Meteor (TOMS-Meteor), ERS-1, JERS-1, ROSAT, and Interplanetary Monitoring Platform (IMP-8). Prime operational support for IUE, ERBS, SAMPEX, COBE, NIMBUS-7, and IMP-8 is also provided by other NASA ground and space network facilities. COBE and NIMBUS-7 operations were discontinued in FY 1994. Operational support for NOAA-9 and -10, which carry NASA Earth science instruments; and Meteosat-2, which supports STS trans-Atlantic emergency landings. was also provided.

In FY 1995, the WFF will add primary operational support for the SWAS, FAST, TOMS-EP. SeaStar, ERS-2. and RadarSat missions. Deployment of the U.S.-Argentine SAC-B aboard a Pegasus launch system will also be supported. Reimbursable support for Ariane deployments of ERS-2 and Helios-1; Conestoga deployment of Comet; and operational support of Express and SFU-1 will be provided. Primary operational support of ADEOS will begin in FY 1996. In FY 1996, reimbursable support for 3 Pegasus launches of Orbcom systems is to be provided.

The upgrade of the WFF will be completed by FY 1997. In FY 1994. systems design was completed, to be followed by installation of data handling systems in FY 1995. In FY 1996, installation of one 11 meter antenna is to be completed followed by a second in FY 1997. FY 1994 also saw continued progress toward establishment of tracking, command and data acquisition facilities at McMurdo Station, Antarctica and at Fairbanks, Alaska in support of the RadarSat and ADEOS missions, respectively. Installation of a 10 meter antenna at McMurdo is scheduled to be completed in FY 1995 and an 11 meter antenna at Fairbanks, Alaska is to be completed in FY 1996.

Demonstration of GPS technology in collaboration with NASA's SSTI program will occur in FY 1996. Two flight qualified GPS receivers and associated software will be deployed aboard the Lewis spacecraft. Development of these articles by NASA's Ground Network program will occur in FY 1995. A GPS time reference and distribution testbed will also be established for receiver development.

BASIS OF FY 1996 FUNDING REQUIREMENT

MISSION TROL AND DATA SYSTEMS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Mission control systems	16,600	12,000	11,300
Mission control operations	54,000	51,300	45,300
Data processing systems	46,381	42,500	41,400
Data processing operations	89.500	70.000	64.200
To	206.481	175.800	162.200

PROGRAM GOALS

To provide reliable. cost-effective mission control and data processing systems and services for space flight missions of the Goddard Space Flight Center (GSFC): data processing for NASA's Spacelab program: and flight dynamics services for NASA flight systems. The Mission Control and Data Systems program also provides for data systems and other telecommunications systems technology demonstrations and initiatives and coordination of data standards and communications frequency allocations for NASA flight systems. The Mission Control and Data Systems program provides for the implementation. maintenance and operation of the mission control and data processing facilities necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems.

The Mission Control and Data Systems program supports NASA's programs in collaborative interagency and international initiatives. Limited flight dynamics support is provided to national. international and commercial enterprises on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

NASA's Mission Control and Data Systems program is comprised of a diverse set of facilities, systems and services required to support NASA flight systems. The Computer Science Corporation and AlliedSignal Technical Services are the support service contractors responsible for ongoing engineering support, development and operations.

The mission control function consists of planning scientific observations and preparing command sequences to be transmitted to spacecraft to control all spacecraft activities. These services range from the relatively inexpensive to the more complex and sophisticated. The Hubble Space Telescope (HST), NASA's most complex spacecraft, requires 10.000 commands per day to carry out its mission. Mission control centers interface with flight dynamics and communications network facilities in preparation of command sequences, perform the real-time uplink of command sequences to spacecraft systems, and monitor spacecraft and

instrument telemetry for health, safety, nd system performance. Real-time man gement of information from costly spacecraft systems is crucial to rapid determination of the condition of the spacecraft and scientific instruments and to prepare commands in response to emergencies.

Mission control facilities operated and sustained under this program are Mission Operations Centers for the HST, the several missions of the International Solar-Terrestrial Physics program, International Ultraviolet Explorer (IUE), Total Ozone Mapping System (TOMS),and Small Explorer (SMEX) programs: and the Multi-satellite Operations Control Center (MSOCC)which serves the Compton Gamma Ray Observatory (CGRO). Upper Atmospheric Research Satellite (UARS), Extreme Ultraviolet Explorer (EWE),Earth Radiation Budget Satellite (ERBS),International Cometary Explorer (ICE),and Interplanetary Monitoring Platform **(IMP-8).**

EWE will be the last satellite controlled by the aging Multi-Satellite Operations Control Center. It and the CGRO system are being transitioned to new Transportable Payload Operations Control Center (TPOCC) architecture of distributed workstations first used for the Solar, Anomalous. and Magnetospheric Particle Explorer (SAMPEX)mission. NASA's SAMPEX, Fast Auroral Snapshot Explorer (FAST), SubmillimeterWave Astronomy Satellite (SWAS)missions will be operated from a common control facility for SMEX missions: TOMS-Earth Probe (TOMS-EP] will likewise be operated from the current TOMS control center. TPOCCs for the X-ray Timing Explorer (XTE), Tropical Rainfall Measuring Mission (TRMM), and Advanced Composition Explorer (ACE) are in development. These workstation systems allow for increased mission control capability at reduced cost.

Other mission control systems include the Shuttle POCC Interface Facility (SPIF)and the Command Management System. The SPIF provides a single interface to the Mission Control Center for the Space Transportation System (STS) for use of spacecraft mission control facilities to access spacecraft to be deployed by the STS. The Command Management System generates all command sequences to be used by mission control centers to support spacecraft systems. A User Planning System (UPS)is provided for scheduling communications with spacecraft supported by the Tracking and Data Relay Satellite System (TDRSS); the Flight-to-Ground Interface Engineering Center provides pre-flight and in-flight simulation and development support for NASA flight systems: and an Operations Support Center maintains status records of in-flight NASA systems.

The data processing function captures spacecraft data received on the ground, verifies the quality of the data and the transmission circuits used to transport the data, and prepares data sets ready for scientific analysis. These facilities perform the first order of processing of spacecraft data prior to its distribution to science operations centers and to individual instrument managers and research teams.

Data processing facilities that provide general services to NASA flight systems include the Packet Data Processing (PACOR) facility and the Telemetry Processing Facility. The PACOR facility, which utilizes a new type of data protocol to ease spacecraft message handling. is to replace the Telemetry Processing Facility, which serves spacecraft employing Generic Time Division Multiplexed (GTDM)message handling, once the latter approach is no longer used by NASA spacecraft. The PACOR system is being upgraded to a distributed workstation environment in order to manage the increasing volume and rate of data processing. An Advanced Orbiting Systems Testbed (AOST) is used to test and support continued standardization of NASA flight system data handling.

Specialized data processing services are provided by the HST Data Capture Facility (HSTDCF).the International Solar Terrestrial Physics DCF. and the Spacelab Data Processing Facility (SLDPF) A Central Data Acquisition Facility provides backup data capture services and the Data Distribution Facility performs electronic media production and distribution of NASA space flight data to interested users. Specialized telemetry processing systems for NASA's Space Network systems are also provided under this program.

a The Mission Control and Data Systems program also provides for the operation, sustainment and improvement of NASA's Flight Dynamic Facility (FDF). The FDF provides orbit and attitude determination for operating NASA space flight systems, including the TDRS and Space Transportation System (STS); develops high-level operations concepts for future space flight systems: modifies existing FDF systems to accommodate future missions: develops mission-unique attitudinal software and simulator systems for specific flight systems: generates star catalogues for general use: and conducts special studies of future orbit and attitude flight and ground system applications. It is critical to continuously know the location of spacecraft so as to communicate with the system and to know the orientation of the spacecraft to assess spacecraft health and safety and to perform accurate scientific observations. The types and level of support required by spacecraft systems is dependent on the design of its on-board attitude and control systems, including its maneuver capabilities, and the level of position and pointing accuracy required of the spacecraft. Automated orbit determination systems for TDRS and other spacecraft systems are also under development. The FDF performs studies of atmospheric. geodetic, geopotential, and Udal effects upon space flight systems: special attention is currently being paid to the geopotential models being developed through support of NASA's Ocean Topography Experiment (TOPEX) mission.

Besides the operation of currently deployed spacecraft and the modification and development of mission control and data processing systems to accommodate flight systems, the Mission Control and Data Systems program also supports the study of future flight missions and ground system approaches not yet approved for development. The more significant investments -- for spacecraft, instrument, science planning and scheduling, and scientific products generation systems -- are made by NASA's strategic enterprises. Mission control and first-order data processing systems are less costly systems. Yet, proper economy of mission planning requires solutions that integrate ground and flight system development considerations. Special emphasis is given by the Mission Control and Data Systems program to seeking integrated solutions to spacecraft and ground system designs which emphasize spacecraft autonomy: ease and low cost of operation: reuse of software: and selected use of advanced technology to increase the return of space flight system investments at equal or lower-cost than is required to support today's mission systems.

NASA's Mission Control and Data Systems program supports two forms of advanced technology: near-term demonstration and application of data management systems and procedures: and more long-range development of ground and space flight communications systems. A Data Systems Technology Laboratory was recently established at GSFC to assess the prospect of various advanced applications in command and control, data processing, flight dynamics, and communications network systems. This facility will be used to examine the feasibility, performance and cost of future applications in the areas of artificial intelligence, expert systems, human factors. distributed systems. remote systems, user interfaces, mission planning and scheduling, very large scale integration (VLSI), mass data storage, object-oriented languages, and high volume/high rate data capture.

More long-range applications being developed under the Mission Control and Data Systems program include the development of low-cost. low-power TDRS user transponders: evaluation of Space Network data modulation and compression strategies: advanced communications receivers: VLSI-based communications gateways: and Ku-band phased array technologies. The Mission Control and Data Systems program also provides for advanced development of a limited number of deep space communications technologies, including Ka-band flight subsystems and Deep Space Network (DSN) antenna calibration.

The Mission Control and Data Systems program also provides the coordination needed to plan for NASA's International Space Station program.

Finally. in order to carry out the duties of the Space Communications program, the Mission Control and Data Systems program also seeks to ensure the availability of adequate allocation of communication frequencies for the performance of NASA flight mission and administrative functions. NASA's Office of Space Communications coordinates licensing arrangements with other U.S. agencies and regulatory groups and the International Telecommunications Union (ITU). In compliance with the 1992 Telecommunications Act, NASA actively participates with the Interdepartment Radio Advisory Committee (IRAC) and working groups of the Federal Communications Commission (FCC) and Department of State.

MEASURES OF PERFORMANCE

	FY 1994	FY 1995	FY 1996
Number of NASA spacecraft supported by GSFC mission control facilities	12	18	19
Number of mission control hours of service	40.000	40.000	40.000
Number of billions of bits of data processed	10,200	12.200	15.500
Number of NASA missions provided flight dynamics services	25	29	30

:OMPLISHMENTS AND PLANS

In FY 1994, mission control was performed for the HST, CGRO, UARS, EUVE, IUE. SAMPEX, ICE, IMP-8, ERBS, TOMS-Meteor. the Cosmic Background Explorer (COBE) and NIMBUS systems: including support for the Hubble Space Telescope First Servicing Mission. Hubble's mission control center was instrumental to the exceptional performance of the First Servicing Mission -- in sequence with each new installation of equipment, the mission control center verified the electrical performance of the systems in real-time, thereby assuring that repairs were successful. Support for NIMBUS-7 and COBE were ended in FY 1994.

In November 1995, the WIND spacecraft was deployed under the control of GSFCs mission control facilities, to be followed by the TOMS-EP, XTE, SWAS, and FAST missions throughout the fiscal year. In FY 1996. deployment of the Solar and Heliospheric Observatory (SOHO) and POLAR missions is planned. Note that the spacecraft managed by GSFCs mission control facilities are supported by various NASA communication networks, including the TDRSS, the DSN. the Wallops Flight Facility (WFF) and transportable ground systems. A wide range of communications and systems interfaces must be managed to accomplish the

function of mission control. Note that NASA mission operations personnel support the planning and development of future mission systems and continuous changes to operational spacecraft software systems, as well as the operation of current ground control systems.

Among systems implementation projects in FY 1994, development of TPOCC systems for the upcoming FAST, SWAS, SOHO. and XTE spacecraft was continued, including the procurement of workstations, processors, and software. TOMS-EP was integrated into the TOMS mission control center. FAST and SWAS mission control systems will be combined into a generic SMEX mission operations center. Modification of the Command Management System for the SOHO mission was also supported. TPOCC development for the CGRO and EUVE missions was initiated in order to allow closure of the aging MSOCC facility by FY 1997. Preparations for the First Servicing Mission for the HST were followed by ongoing ground system software changes to improve observation scheduling and operations.

In FY 1995. SOHO .XTE, SWAS, and FAST mission control centers will be completed prior to their deployment. and procurement of systems for the TRMM and ACE missions will be initiated. Emphasis upon artificial intelligence applications and advanced graphical displays will accelerate with the latter procurements. NASA's Command Management System will be maintained in its current form. pending the results of further studies of the future configuration of NASA mission control systems. In FY 1996, conversion of CGRO and EUVE to TPOCC systems is to be completed: support for the HST Second Servicing Mission will accelerate: TRMM and ACE control systems procurement will be completed: and transition to support of the next series of SMEX missions will begin.

In FY 1994. packet data processing operations were provided for the HST, CGRO, EUVE, SAMPEX, and Geotail missions. The GTDM services were provided for the UARS, ERBS. ICE, IMP-8, and NOAA-10 systems. Data processing of the Spacelab missions was also performed. In FY 1995. GTDM services were initiated for the WIND mission, and will continue for the POLAR mission upon its deployment. The XTE and SWAS missions will also be supported by GSFC's data processing program in FY 1995: operational support for SOHO will begin in FY 1996.

Beginning with the Atmospheric Laboratory for Applications and Science (ATLAS-3) mission, all Spacelab data processing was consolidated with the Spacelab mission control facility at the Marshall Space Flight Center (MSFC) at reduced cost.

Development of the PACOR II upgrade continued in FY 1994, and will proceed with the completion of the core processing system in FY 1995. Current PACOR supported missions will be accommodated by the upgraded system: additional changes to the system will support the SOHO, SWAS, and XTE missions. In addition to these flight programs, preparation for the TRMM mission and other follow-on SMEX missions will continue through FY 1996 for future year deployment.

Flight dynamics services were provided to all NASA space flight missions which utilize NASA's Space Network and selected elements of the Ground Network, including the STS, expendable launch vehicles (ELV), and satellite systems. Orbit and attitude control of the TDRS itself is also provided. In FY 1994. reimbursable support for the SPOT-3. GOES-Next. DSPSE, and 3 commercial ELV deployments was performed. In FY 1995, operational orbit determination for the WIND, SOHO, XTE, SWAS, FAST, and TOMS-EP will be added: reimbursable support is to be provided for 7 missions, including the HELIOS-1, Earth Remote

Sensing Satellite (ERS-2), S C-B and GOES an NOAA programs. Support for the POLAR mission will begin in FY 1996. Mission planning for the future ACE, Transition Region and Coronal Explorer (TRACE). Wide-field Infrared Explorer (WIRE), Far Ultraviolet Spectroscopic Explorer (FUSE). Landsat-7, and Earth Observing System (EOS) missions is supported.

Attitudinal software and simulator development is being provided for the SOHO, XTE, SWAS, FAST, TOMS-EP. TRACE. WIRE, ACE, TRMM, EOS-AM. and Landsat-7 flight systems. Specification of requirements to transition the FDF to a workstation environment will continue in FY 1996.

In FY 1994, transfer of data systems technologies to flight project use occurred in the areas of software reuse, VLSI applications, expert system monitoring of spacecraft control functions, and packet data processing systems. Software reuse. expert systems, VLSI, user interface, workstation environments, and object-oriented language applications will continue through FY 1996, including application of new technologies to the EOS Data Information System (EOSDIS). Continued exploration of the promise of advanced communications technologies will continue throughout this period.

In FY 1994, NASA actively supported the objectives of the United States of America at the 1994 ITU Plenipotentiary Conference: preparations are underway to continue this support at the FY 1995 and FY 1997 World Radio Conferences (WRC).

BASIS OF FY 1996 FUNDING REQUIREMENT

SPACE NETWORK CUSTOMER SERVICE

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Space network customer service	30,000	32,000	30.300

PROGRAM GOALS

To provide reliable, cost-effective user access to NASA's space-based tracking. command and data acquisition systems and selected elements of NASA's Ground Network system. These services are provided for NASA's Human Space Flight program, other low-Earth orbiting science missions, including observatory-class systems, and selected sub-orbital flight systems. The Space Network Customer Service program provides for the implementation, maintenance and operation of the network control and scheduling facilities of the Space Network and selected elements of NASA's Ground Network necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems.

The Space Network program supports NASA's programs in collaborative interagency, international. and commercial enterprises: and independently provides support to other national and commercial space-faring enterprises on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

The Space Network Customer Service program provides user access to NASA's Tracking and Data Relay Satellite (TDRS) System (TDRSS) and selected elements of NASA's Ground Network. This function is performed by the Network Control Center (NCC) located at the Goddard Space Flight Center (GSFC). The NCC provides user scheduling, remotely configures the TDRSS ground terminals and satellites, and provides network fault isolation services. The NCC also performs scheduling for the Spaceflight Tracking and Data Network (STDN) and coordinates support of the Wallops Flight Facility (WFF) and the Deep Space Network (DSN), elements of NASA's Ground Network, on behalf of NASA's Human Space Flight program. The NCC also controls the STDN. including all fault isolation and service evaluation functions, for the deployment of expendable launch vehicles (ELV) from the Canaveral Air Force Station. The Computer Science Corporation provides the primary systems engineering, software development and maintenance, and analytical services. AlliedSignal Technical Services Corporation provides operations and maintenance personnel as well as some specialized engineering, analysis, and software development tasks.

The NCC serves as a common interface for the flight systems it supports. Tracking, command and data acquisition requirements of user flight systems are coordinated by mission control facilities with the NCC. Schedules to access user spacecraft via the TDRSS are established prior to the scheduled event: re-scheduling is performed as necessary: and command uplink or downlink is performed. NASA's Flight Dynamics Facility (FDF) also supports these efforts by providing predictions of user and TDRS

spacecraft locations and attitudes. The Bilateration Ranging and Tracking System (BRTS), also funded by the Space Network Customer Service program, provides precise determinations of the TDRS spacecraft position necessary for accurate user spacecraft tracking.

The NCC also coordinates the use of NASA's Ground Network facilities in support of the launch, emergency access, and landing of the Space Transportation System (STS). In addition, the NCC coordinates the NASA Ground Network facilities support for the Department of the Air Force's Eastern Launch Range.

In addition, the Space Network Customer Service program provides simulation and testing to ensure telecommunications network readiness and compatibility of flight and ground communication systems. NASA's Simulations Operations Center (SOC) emulates Space Network, Ground Network, and user spacecraft and mission control facilities, including the Johnson Space Center Mission Control Center, and Hubble Space Telescope Operations Control Center. A Radio Frequency Simulations Operations Center (RFSOC) provides forward and return link access to the TDRS spacecraft and also serves as a spacecraft emulator for support of TDRS testing and evaluation. NASA's Compatibility Test Van (CTV) provides a transportable test capability for user systems; it supports radio frequency link assurance for Space Network, STDN, WFF, and Transportable Orbital Tracking Station (TOTS) supported systems. End-to-end compatibility verification can be performed using the CTV as an RF link between network and mission control facilities and user spacecraft prior to shipment from the manufacturer's plant. This capability also allows for advanced flight operations team training. SOC and CTV services are provided to international, other U.S. agency and commercial enterprises on a reimbursable basis.

The development, upgrade, maintenance and operation of the NCC, SOC, and CTV are provided by the Space Network Customer Service program. The NCC is being upgraded to accommodate the new TDRSS ground terminals and to enhance user scheduling services of the NCC. SOC, RFSOC, and CTV systems are being upgraded due to system obsolescence and the need to incorporate digital technology in support of future high data rate systems.

A new initiative to develop a low-power, low-weight transponder system for spacecraft applications, co-funded under the Mission Control and Data Systems long-range technology program and the Space Network Customer Service program, promises to expand the scope and number of users of the TDRSS. This project will produce a number of flight qualified units for use by several NASA flight systems.

NASA's Space Network Customer Service program also provides mission planning for NASA flight missions and engineering support for the TDRSS ground terminals, including adaptation of TDRSS to meet specific user needs and assistance in testing and demonstrating emerging communications technology and procedures. TDRS spacecraft are being made available to industry for test and demonstration of new mobile satellite systems, including remote hand-held terminals, personal communications services, and digital broadcast of compact disk quality radio applications . In addition, development of low power, portable transmit/receive terminals which operate with TDRS spacecraft is underway; potential applications include ocean buoy data collection, data collection from Antarctic sites, and the interagency environmental science and education Global Observations to Benefit the Environment (GLOBE) program. A series of tests with future Japanese and European data relay satellite systems will be conducted to explore interoperability with Space Network for emergency operational support of NASA spacecraft.

MEASURES OF PERFORMANCE

	FY 1994	FY 1996	FY 1996
Number of Space Network spacecraft events supported by the NCC	57,333	63,700	68,700

ACCOMPLISHMENTS AND PLANS

In FY 1994, the TDRSS Space Network provided support for the Hubble Space Telescope (HST) First Servicing Mission and 6 other missions of the STS, including the Space Radar Lab (SRL-1), Spacehab-2, International Microgravity Lab (IML-2), and Space Life Sciences (SLS-2). Operational support was also provided to the Compton Gamma Ray Observatory (CGRO), the Upper Atmosphere Research Satellite (UARS), the Earth Radiation Budget Satellite (ERBS), the Extreme Ultraviolet Explorer (EUVE), the Ocean Topography Experiment (TOPEX). Space Network support is also provided for classified users of NASA's Space Network system. The NCC also supported interface testing of the new Danzante, or Second TDRSS Ground Terminal (STGT), in FY 1994, including software changes to the NCC needed to accommodate dual ground terminals.

SOC and CTV support was provided for missions of the STS and for NASA's Fast Auroral Snapshot Explorer (FAST), Submillimeter Wave Astronomy Satellite (SWAS), WIND, POLAR, Solar and Heliospheric Observatory (SOHO), X-ray Timing Explorer (XTE), Total Ozone Mapping System-Earth Probe (TOMS-EP), and Long Duration Balloon programs. Support was also provided for the new Danzante ground terminal and in preparation for deployment of the TDRS Replacement Spacecraft. Reimbursable support was provided for the Geostationary Operational Environmental Satellite (GOES-Next), NOAA-K, and RadarSat programs.

In FY 1995, XTE, the Long Duration Balloon Program, and NASA's ER-2 high altitude Earth sciences aircraft will be added to the workload of the TDRSS Space Network. The NCC will also support the deployment of the TDRS Replacement Spacecraft. Seven flights of the STS are planned, including Spacehab-3, U.S. Microgravity Lab (USML-2), Atmospheric Laboratory for Applications and Science (ATLAS-3), SRL-2, Astro-2, and the first Shuttle/MIR rendezvous. Continued support for TDRSS ground terminal testing is planned.

Modification of NCC software to operate more than three TDRS spacecraft will be completed in FY 1995, allowing for the operation of partially failed TDRS spacecraft. SOC and CTV support for aforementioned space flight systems still in development will continue; support for the Universal Spacecraft Clock Calibration System will also be provided. Upgrade and automation of the SOC RF equipment will also begin in FY 1995.

No new robotic spacecraft missions are to be added to the Space Network workload in FY 1996. Seven flights of STS are scheduled, including Tether Satellite System, Spacehab-4, Life and Microgravity Spacelab, and three additional Shuttle/MIR rendezvous missions. SOC and CTV support is planned for the missions of the STS and NASA's SWAS, SOHO, Tropical Rainfall Measurement Mission (TRMM), follow-on Small Explorers, Landsat-7, and EOS programs. Reimbursable support for GOES-Next will also be provided.

Development of an improved, distributed architecture scheduling system for the NCC will begin in FY 1996. When completed, this system will provide more efficient use of the network capabilities and improved ability to resolve scheduling conflicts among user missions. A cooperative effort, jointly funded with the Ground Network program, will initiate development of a radio frequency interface in Antarctica for access to the Space Network. This capability will allow rapid retrieval of science data from the Canadian RadarSat mission for real-time, quick-look data validation; this application also may be used for other polar orbiting systems.

Academic
Programs

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	Page Number
Education	54,300	56,300	61.400	SAT 7.1-1
Minority research and education	31,200	45,900	57.300	SAT 7.2-1
To	85,500	102.200	118.700	

Education
Programs

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

EDUCATION PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	page Number
Student programs	10.700	11.200	11.200	SAT 7.1-4
Teacher/faculty	12.000	14.300	15.500	SAT 7.1-7
Systemic change	26.500	26.400	29.500	SAT 7.1-11
Education technology	5.100	3.900	4.200	SAT 7.1-16
Evaluation	--	500	1.000	SAT 7.1-18
Total	54.300	56.300	61.400	

Distribution of Program Amount by Installation

Johnson Space Center	285	295	322
Kennedy Space Center	120	124	135
Marshall Space Flight Center	1.472	1.526	1.664
Stennis Space Center	845	876	955
Ames Research Center	646	670	731
Langley Research Center	413	428	467
Lewis Research Center	1.362	1.412	1.540
Goddard Space Flight Center	421	468	510
Jet Propulsion Laboratory	597	619	675
Headquarters	48.139	49.882	54.401
Total	54.300	56.300	61.400

ACADEMIC PROGRAMS

EDUCATION PROGRAMS

PROGRAM GOALS

The goal of NASA's academic programs is to promote excellence in the United States' education system through enhancing and expanding scientific and technological competence. This is in keeping with the Administration's *Goals 2000:* Educate America agenda and in support of three of the National Goals for Education, relating to competency in challenging subject matter. achievement in science and mathematics. and science and technology literacy for responsible citizenship.

STRATEGY FOR ACHIEVING GOALS

NASA's Education programs use NASA's unique mission and results to capture and channel student interest in science, engineering, mathematics and technology, as well as enhance teacher and faculty knowledge and skills related to these subjects. These programs reach students in the pre-college grades, with workshops for teachers to enhance their content knowledge, especially in aeronautics, sciences, engineering and technology. as well as opportunities for students to explore their interest in science, mathematics, engineering and technology. At the Undergraduate and Graduate level, programs are geared to providing opportunities for students and faculty to participate in NASA-sponsored research activities at NASA Field Centers. NASA has actively supported efforts of the education community to implement voluntary national education standards in mathematics and science by: 1) developing standards based supplemental curriculum materials based on the NASA mission: 2) increasing the number and duration of teacher enhancement workshops, emphasizing standards based scientific content and pedagogy: 3) supporting existing NSF systemic initiatives and: 4) developing teaching tools that combine innovative technologies with NASA's scientific results to enhance the educational process and embrace lifelong learning.

NASA's Education Strategic Plan contains four goals which guide the activities of the NASA Education program:

- Maintain that segment of NASA's current education program that is judged to be effective, as determined by internal and external customer measures of success:

- Implement new education reform initiatives that specifically address NASA mission requirements, national education reform, and National Science and Technology Council/Committee on Education and Technology priorities:

- Expand significantly the impact of the NASA Education program by developing partnerships with key external constituencies;

- Implement an agency-wide education program and evaluation framework, to bring organization. focus and accountability to the agency's efforts in education.

NASA is actively involved in the efforts of the National Science and Technology Council/Committee on Education and Training (NSTC/CET). This Committee includes 18 federal agencies, and is charged to work as a team in meeting the goal of ensuring U.S. world leadexship in education and building a highly trained workforce. The NSTC/CET has identified strategies to meet this goal that delineate goals and research priorities to guide the work of agencies in research and development in education. NASA's program supports the strategy outlined by the NSTC/CET.

BASIS OF FY 1996 FUNDING REQUIREMENT

STUDENT PROGRAMS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Elementary and secondary	3,100	3,700	3,600
Higher education	7,600	7,500	7,600
Total	10,700	11,200	11,200

PROGRAM GOALS

The goals of the Student Programs are: to provide experiences and exposure to NASA's mission: to provide research experiences for students at NASA and related sites: and to provide support to train students in sciences, mathematics, engineering and technology.

STRATEGY FOR ACHIEVING GOALS

Elementary and Secondary

At the Elementary and Secondary level, student support activities: provide experiences and information that encourages student interest in mathematics, science, engineering and technology: and provide exposure to research and/or research experiences to promote mathematics, science, engineering and technology awareness. At the elementary and secondary level, activities such as the Space Science Student Involvement Program (SSIP), the Shuttle Amateur Radio Experiment (SAREX), and science and engineering fairs provide general exposure to NASA's mission, stimulate interest in aeronautics. space and Earth sciences, and encourage students to become interested in and pursue coursework in mathematics, science, and technology subject matter. Additional activities such as the Summer High School Apprenticeship Research Program (SHARP), and SHARP-PLUS, demonstrate the applications of mathematics, science and technology by providing research experiences for minority students who traditionally have not been represented in mathematics. science and engineering fields.

Higher Education

At the higher education level, student support activities: provide exposure to and involvement in research activities; provide experiences that facilitate the transition from undergraduate work to graduate studies in NASA related interest areas: provide financial support for students to pursue studies in NASA-related fields: and encourage continuing professional development and contributions to research in NASA related disciplines. At the higher education level, activities such as the Graduate Student

Researchers Program **(GSRP)** provides support to train students in NASA related disciplines at both the master's and doctoral levels.

An objective at all levels is to increase the participation of underrepresented groups (such as African Americans, Hispanics, Native Americans, Pacific Islanders, women. and individuals with disabilities). *All* student support activities have these as a core set of objectives.

MEASURES OF PERFORMANCE

Elementary and Secondary	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate
Space Science Student Involvement Program (SSIP)			
Student participants:	75,000	100,000	125,000
Entries/proposals:	4,200	7,000	9,000
Teacher participants:	600	1.000	1.200
Awards:	13	13	13
SHARP/SHARP-PLUS			
Student participants:	400	500	500
Participating field centers:	8	8	8
University sites:	10	15	15
SAREX			
Student participants:	9.400	10,000	10.000
Higher Education			
GSRP			
Student participants:	498	510	510
Universities:	114	117	117

Currently, program activities in the above categories have a variety of evaluation mechanisms. In FY 1995, a high priority activity will be to further develop key indicators as standards by which all program activities will be measured. These could include such outcomes as change in student interest, career aspirations/awareness, educational aspirations: participation in research activities: persistence to undergraduate or graduate degree: career path; career productivity; participation in other NASA programs: and increased participation of underrepresented groups.

ACCOMPLISHMENTS AND PLANS

Elementam and Secondary

The student support programs, implemented to provide experiences and exposure to NASA's mission are: *SHARP*. SHARP-PLUS. SSIP and SAREX at the Elementary and Secondary level, and GSRP at the Higher Education level. These are a series of programs that capture interest in mathematics, science and technology, and channel that interest into mathematics. science and technology career paths. In FY 1994, the SHARP and SHARP-PLUS program encouraged more than 400 underrepresented minority high school students to participate in intensive research apprenticeships with NASA and active industry and university scientists and engineers. By the time this program is fully implemented in FY 1996. the program will involve 550 students.

The Space Science Student Involvement Program (SSIP) is another very effective program that encourages students to work toward scientific literacy through the motivating topic of space. In FY 1994. more than 240,000 materials were distributed to elementary and secondary schools, providing opportunities for 600 teachers and 75.000 students to participate and enter contests to demonstrate the students' skills in science as well as art. graphics, and writing. By FY 1996, the program will include fourteen competition activities, encompassing all 50 states, Puerto Rico and the District of Columbia through eight geographical regions. Program participation will expand from 100.000 students to 300,000.

The Shuttle Amateur Radio Experiment (SAREX) involves amateur radio clubs at elementary, junior high and high schools in shuttle missions by providing the opportunity for students to talk to astronaut operators via amateur radio. During FY 1994, more than 9,000 students were involved and the program is expected to include approximately the same number of students in FY 1995 and FY 1996.

Higher Fducation

At the Higher Education level, the GSRP, initiated in 1980, provides graduate fellowships nationwide to post-baccalaureate U.S. citizens to conduct thesis research. Awards are made to a graduate student for a maximum of three years. On an annual basis, NASA supports approximately 500 graduate students pursuing the masters or doctorate degrees in science, engineering. mathematics, and technology. The request in FY 1995 and FY 1996 for Higher Education will maintain the fellowships at the current level. This program continues to be a very competitive program, with a 6 to 1 ratio of applications to awards.

BASIS OF FY 1996 FUNDING REQUIREMENT

TEACHER/FACULTY PROGRAMS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Elementary and secondary	2.200	4,600	5.700
Higher education	9,800	9,700	9,800
To	12,000	14,300	15,500

PROGRAM GOALS

The goal of the Teacher/Faculty program is to enhance teacher/faculty knowledge and skills, using the NASA mission, facilities. and resources, with the intent of producing positive student outcomes.

STRATEGY FOR ACHIEVING GOALS

Elementary and Secondary

At the Elementary and Secondary level, preparation and enhancement activities utilize the NASA mission and the process by which new knowledge is discovered to: provide workshops that demonstrate the application of mathematics, science and technology in student learning; enhance teachers' capability to design lessons and experiences that use scientific inquiry to affect student learning; encourage a "multiplier" effect to extend the benefits of the in-service program beyond participants to other teachers and students; provide access to and promote utilization of NASA related materials and information resources; and encourage collaboration between Facilities of Education. Science and Engineering. to develop innovative approaches to teacher preparation for student learning. At the Elementary and Secondary level, programs such as NASA Education Workshops for Elementary School Teachers (NEWEST), NASA Education Workshops for Math and Science Teachers (NEWMAST), Teaching from Space, and Urban Community Enrichment Program (UCEP) are designed to enhance and improve the teaching of mathematics, science, and technology by demonstrating their applications in aeronautics and space.

Higher Education

At the higher education level, Teacher/Faculty Program activities: enhance faculty research skills: enhance faculty content knowledge, especially in aeronautics. sciences. engineering, and technology; balance participation so that a cross-section of colleges and universities is represented (i.e. community colleges, four year institutions, institutions that serve significant numbers of underrepresented groups, underfunded institutions); and provide opportunities for curriculum expansion/revisions that align with the mission needs of NASA and universities. At the higher education level, activities such as the Summer Faculty Fellowship

Program (SFFP) and the NASA/University Joint Venture (JOVE) Program provide research experiences for faculty at NASA field centers to further their professional knowledge in the engineering and science disciplines, and to ultimately enhance the undergraduate/graduate curriculum.

- An objective at all levels is to increase the participation of underrepresented groups (such as African Americans, Hispanics, Native Americans, Pacific Islanders, women, and individuals with disabilities).

MEASURES OF PERFORMANCE

Elementary and Secondary	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate
NEWEST/NEWMAST			
In service workshops:	9	9	11
Teachers:	215	215	265
UCEP			
Teachers:	700	750	750
Students:	17,500	18,700	18,700
Schools:	70	80	80
Teacher Enhancement Workshops			
Teachers:	190	300	500
Higher Education			
Summer Faculty Fellowship Program			
Fellowships:	290	290	290
Colleges/universities:	185	185	185

	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate
JOVE			
Faculty members:	178	178	178
New courses:	32	35	35
New majors and minors:	2	3	3
Papers presented (faculty):	134	140	140
Papers presented NCUR (students):	22	25	25
Innovative Research			
Research grants:	21	22	22

Currently, program activities in the above categories have a variety of evaluation mechanisms. In FY 1995. a high priority activity will be to further develop key indicators as standards by which all program activities will be measured. These could include such outcomes as change in student interest, career aspirations/awareness, educational aspirations: participation in research activities: persistence to undergraduate or graduate degree: career path: career productivity: participation in other NASA programs; and increased participation of underrepresented groups.

ACCOMPLISHMENTS AND PLANS

Elementary and Secondary

By targeting educators as part of NASA's education strategy, programs such as NEWEST and NEWMAST, Teacher Enhancement Workshops, Teaching from Space, and UCEP, play a significant role in ensuring that students and educators alike are provided today with the tools they will need tomorrow. The FY 1996 funding will allow for expansion of NASA sponsored teacher workshops (NEWEST and NEWMAST) and increased participation in a National Science and Technology Council/Committee on Education and Training (NSTC/CET) program for long-term teacher enhancement activities. In FY 1993, NASA participated in a NSTC/CET pilot program for long-term teacher enhancement where teachers were given a month of in-service and work related opportunities at the Marshall Space Flight Center and the Jet Propulsion Laboratory. The cost is approximately $5,000 per teacher. In FY 1994. the pilot program was expanded to include opportunities at 8 of 9 NASA Field Centers and will have 180 teachers funded in FY 1995.

Higher Education

The SFFP provides highly beneficial opportunities for U.S. citizen engineering and science faculty throughout the nation to participate in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefits NASA, universities, faculty, students and the Nation. Approximately 300 university faculty are supported annually for ten weeks. Evaluations of the program, conducted by the American Society for Engineering Education

Higher Education

The SFFP provides highly beneficial opportunities for U.S. citizen engineering and science faculty throughout the nation to participate in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefits NASA, universities, faculty, students and the Nation. Approximately 300 university faculty are supported annually for ten weeks. Evaluations of the program, conducted by the American Society for Engineering Education (ASEE), indicate that approximately 30-40% of the participating faculty subsequently receive NASA research grants or contracts. Program emphasis in FY 1995 will be curriculum development and to broaden the base of participating institutions.

The JOint VEnture (JOVE) and Innovative Research programs also provide opportunities for college and university faculty to come to the NASA Centers to work with NASA data and to enhance research and teaching capabilities. JOVE is managed by the Marshall Space Flight Center, where it was initiated as a pilot program in FY 1989. NASA provides scientific on-line data from space missions, as well as support for electronic work stations and partial faculty and student support. In turn, the universities agree to grant faculty release time. student support. and an instructional unit on a space science topic. There are currently 75 academic institutions in 44 states and Puerto Rico participating. This program allows NASA to provide data to a broader range of academic institutions.

The Innovative Research program is managed through the Offices of Space Science and Mission to Planet Earth. to support research which has the potential for significant advances for Planetary and Earth Science and Astrophysics. This program is intended to provide a mechanism for the funding of scientifically sound proposals which might not be funded through normal channels either because of their interdisciplinary nature or because they are speculative or risky. The long-term goal is to help the new ideas mature to a state of acceptability within a particular science discipline.

The FY 1995 and FY 1996 funding for Higher Education will provide for continuation of ongoing projects and a limited number of new awards.

BASIS OF FY 1996 FUNDING REQUIREMENT

SYSTEMIC CHANGE

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Aerospace education services program (AESP)	6.300	6,200	6.300
Space grant college and fellowship program (SGCFP)	14,500	14,600	14,600
Experimental program to stimulate competitive research (EPSCoR)	5,000	4,900	5.900
Innovative reform initiatives	700	700	2,700
To	26,500	26,400	29,500

PROGRAM GOALS

The goal of the Systemic Change program is to enhance capabilities of the educational community through individual/ collaborative effortswith a range of partners and/or through infrastructure changes.

STRATEGY FOR ACHIEVING GOALS

Elementary and Secondary

Systemic Change activities at the Elementary and Secondary level use NASA personnel and resources to contribute to K-12 mathematics, science, and technology education reform by promoting the involvement of various community sectors; and enhance the participation of schools and organizations serving a significant number of underrepresented groups. A major outreach program at the elementary and secondary education level is the Aerospace Education Services Program (AESP), also known as Spacemobile. The AESP specialists, all former science. mathematics, or technology teachers, capture the interest of millions of students and enhance the teaching skills of teachers each year by using aeronautics and space as a catalyst in the teaching of science, mathematics. and technology. The AESP specialists visit schools throughout the U.S. conducting teacher workshops and student programs. The AESP specialists also conduct teacher workshops at the NASA Centers and various colleges and universities.

Higher Education

Systemic Change activities at the higher education level enhance the research and educational capabilities of the higher education community through activities conducted through partnerships. linkages, and collaborations: and enhance the collaborative capabilities of a diverse set of academic institutions serving a significant number of underrepresented groups. Programs such as

and Innovative Reform Initiatives play a major role in NASA's contribution toward the Nation's systemic educational reform movement.

The SGCFP is composed of three interrelated elements: Designated Space Grant Colleges/Consortia, Space Grant Program Consortia, and Space Grant Capability Enhancement Consortia. All consortia contain academic, industry, and governmental affiliates. The 21 Designated Space Grant Consortia were selected in FY 1989 and are led by preeminent institutions which are substantially involved in a broad spectrum of NASA research. offer advanced study in aerospace fields. and are significantly involved in related public service. In FY 1992, FY 1993, and FY 1994, designated schools received grants ranging from $295,000-$380,000.

In FY 1991, a second competition took place to select states for Program Grants or for Capability Enhancement Grants (the difference between the two types of programs is related to cumnt involvement in aerospace fields). Twenty-nine proposals were received. Of those 29. fourteen were funded as Program Grants, twelve as Capability Enhancement Grants and three as planning grants. Selections were announced in February 1991. Program Grant and Capability Grant awardees received $150.000 in FY 1991, a portion of which was to be used for fellowships. In FY 1992, FY 1993, and FY 1994, the states received an additional augmentation of $20.000, with the opportunity to receive an additional $35,000, depending upon the size of the consortium. The three states which received planning grants of $25,000 each, were brought into the program as fully-funded Capability Enhancement grantees, along with Vermont and Puerto Rico, in FY 1992.

Institutions of higher education involved in the Space Grant program currently number over 400. All consortia match their program grants at 100% in either dollars and/or cost sharing arrangements to cany out programs of education, public service, and research.

In addition to the very successful SGCFP, the FY 1993 NASA Authorization Act (P.L. 102-588) directed NASA to initiate a program to strengthen the research capability of states that do not successfully participate in competitive space and aeronautical research activities. This program, modeled after the National Science Foundation's EPSCoR provides seed funding that will enable eligible states to develop an academic research enterprise directed toward long-term, self-sustaining. nationally competitive capability in space science and applications, aeronautical research and technology, and space research and technology programs. This capability will, in turn, contribute to the state's economic viability.

Systemic change at both elementary and higher education levels is captured in NASA's Innovative Reform Initiatives program which is supportive of standard-based systemic reform efforts and NSTC/CET priorities, and focuses on science, mathematics and technology education. A means of accomplishing systemic reform is through partnerships with professional education associations. national aerospace education associations, industries, other Federal agencies, and state and local groups. When NASA becomes a partner with these groups, its role fluctuates between providing leadership. being a participant, or acting as a facilitator to empower and enable wide reaching educational reform that is systemic in nature. Examples of these partnerships are: the M-State Education Initiative (TSEI), the NASA Industry Education Initiative (NIEI) and the Aerospace Education Alliance Initiative.

MEASURES OF PERFORM

	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate
AESP			
Elementary and secondary students:	670,012	600,000	500,000
Elementary and secondary teachers:	17.152	21,000	22.000
Schools visited:	1,588	2,000	2.000
Classrooms visited:	2,766	3,000	3.000
National Space Grant College and Fellowship Program			
Space grant consortia	52	52	52
Institutions:	525	550	550
Fellowships awarded:	1,600	1,600	1,600
Higher education programs:	283	308	333
K-12 programs:	400	350	325
General public service programs:	400	350	250
EPSCoR			
Awards	6	6	14
Innovative Reform Initiatives			
Public schools systems:	30	45	60
Schools:	231	346	460
Students:	101,800	150,000	200,000
Teachers:	5,600	84,000	1,120

Currently, program activities in the above categories have a variety of evaluation mechanisms. In FY 1995, a high priority activity will be to further develop key indicators as standards by which all program activities will be measured. These could include such outcomes as the establishment of partnerships; increased resources (people, funding, facilities, equipment): and new ways of conducting business.

ISHMENTS AND ANS

The systemic change programs address many different levels within the education community and include: the Aerospace Education Services Program (AESP), Space Grant College and Fellowship Program (SGCFP), Experimental Program to Stimulate Competitive Research (EPSCoR), and the Innovative Reform Initiatives.

AESP

In FY 1994. the format of the AESP was redesigned; new training and program delivery strategies were implemented to include more teacher enhancement emphasis and support of the National Science Foundation systemic change initiatives. Additionally. a pilot was established in FY 1994 to reformat the specialists role from a school consultant to a NASA state/regional level consultant. Funding in FY 1995 and FY 1996 will continue operation of this program.

Space Grant College and Fellowship Program

In FY 1994, an extensive evaluation of the 52 consortia was conducted. Each consortia was graded on the bases of: (1) a detailed self evaluation; (2) database entries on each consortia: and (3) a measure of consortia responsiveness to NASA requirements. The result of this evaluation was that 39 consortia received new five-year awards and 13 consortia received one-year awards with detailed instructions on improvements that would be required to receive additional yearly awards. In FY 1995 and FY 1996, Space Grant plans to initiate a competition for Program Grants to move to Designation status.

Further substantive work in industry-Space Grant relations is planned. Focus will be placed on the following Space Grant content areas: undergraduate training; community colleges: K-12 components which support national education reform, and a continued effortto bring more members of underrepresented groups into Space Grant management, as well as fellowship awards.

EPSCoR

A program announcement was issued in June 1993 advising twenty eligible states of the opportunity to submit proposals for the NASA EPSCoR program. Nineteen proposals were received, and after an extensive merit based review, involving peers from university and industry as well as representatives from NASA headquarters and field centers, Alabama, Arkansas, Kentucky. Louisiana, Montana, and Puerto Rico were selected to receive $500,000 annual awards for three years.

FY 1995 marks the second year of the NASA EPSCoR program with funding continued for the original six awardees. In addition, opportunities are being made available to the 13 non-selected states to build upon highly rated research areas from the original proposals. These opportunities will be in the form of research grants or participation in existing NASA education programs, and are designed to enhance proposal competitivenessfor the next round of EPSCoR selection. An announcement for the next round of NASA EPSCoR awards will be issued in spring 1995, with selection of up to eight states scheduled for early calendar year 1996.

In addition to making second round selections, FY 1996 will be the third year of funding for the original six awardees. At the end of the third year, an assessment will be made based on an evaluation of the extent to which the goals stated in the program announcement and in the original proposal have been achieved. Progress towards these goals will be evaluated through site visits by outside evaluators and by reference to indicators. These states showing successful progress toward stated goals will qualify for an additional two-year award. As the selected states are also part of the Space Grant College program, the two programs are being closely coordinated.

Innovative Reform Initiatives

The Tri-State Education Initiative is achieving systemic education reform through a consortium of 30 school districts by creating an interconnected. high technology learning environment in Alabama, Tennessee and Mississippi. NASA leads the effort with 19 other Federal agencies and 35 national and international corporations reaching 5.600 teachers. 102.000 students and thousands of community members. The Systemic Cooperative Model, developed by this initiative, is now being replicated in many areas throughout the nation.

The NASA Industry Education Initiative is another example of the power of partnerships. On November 15, 1994, Chief Executive Officers of the nation's 28 largest aerospace contractors teamed with NASA and the U.S. Department of Education in an ambitious plan to achieve the nation's mathematics, science and technology education goals.

The Aerospace Education Alliance is a cooperative venture of the nation's five leading aerospace education organizations -- the U.S. Space Foundation. Young Astronaut Council, Challenger Center for Space Science Education. U.S. Space Camp and Space Academy, and the Astronaut Memorial Foundation. Working together. using space as a unifying and inspiring educational theme, the alliance will build on the success of the current programs each of the organizations offers to implement a coordinated strategy to support change in America's K-8 teaching process.

BASIS OF FY 1996 FUNDING REQUIREMENT

EDUCATION TECHNOLOGY

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Education technology..	5,100	3,900	4,200

PROGRAM GOALS

The goal of the Educational Technology program is to provide products and services that facilitate the application of technology to enhance the educational process for formal education and lifelong learning.

STRATEGY FOR ACHIEVING GOALS

The Education Technology program uses technology to support new models of learning and teaching for students. The teaching and learning tools developed through this program combine the unique NASA mission and innovative technology and networking applications to stimulate student interest in math, science and technology. Educational Technology activities produce teaching tools (e.g. CD-ROM databases, live or taped video, computer software, multimedia systems, virtual reality) and instructional materials for their most effective use. These tools use existing technology as well as emerging technologies to facilitate education programs which support the achievement of national education standards. This program also conducts research into new teaching and learning practices that are made possible with technology. NASA's strategy for educational technology has been developed in close alignment with the NSTC/CET Subcommittee on Research and Development in Education and Training.

MEASURES OF PERFORMANCE

Astronomy Village May 1995	Development of interactive multimedia program to supplement high school science curricula.
Educational Multimedia showcase Classroom of the Future May 1995	Begin operation of a 21st century learning center, to develop multimedia curriculum products based on existing and emerging learning technology. Facility includes distance learning facility. video production equipment for education videos. teacher resource center, Challenger learning center for learning science in an interactive environment.
BioBLAST FY 1996	Development of computer simulation curriculum package in which students manage missions aboard the International Space Station and a mission to Mars.

ACCOMPLISHMENTS AND PLANS

During FY 1994. two major curriculum packages which utilize advanced educational technologies and which are aligned with emerging national curriculum strategies were developed. The first, Interactive NOVA Earth, is a high school course in Earth Systems Sciences. The second, Astronomy Village, is an 11th grade, 10-week course in Astronomy. Both packages incorporate state-of-the-art interactive strategies delivered on optical media (i.e. videodisk and CD-ROM respectively). Additionally, both underwent extensive formative evaluation and field testing in preparation for distribution to schools. These packages, as well as others (e.g. Liftoff to Learning), will be made widely available to schools nationwide. In FY 1995, additional tools will be developed to build upon the success of Interactive NOVA and Astronomy Village.

BASIS OF FY 1996 FUNDING REQUIREMENT

EVALUATION

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Evaluation	--	500	1,000

PROGRAM GOALS

The goal of the Evaluation program is to: (a) provide documented evidence of the degree to which NASA's educational program, with its associated projects and activities, has accomplished its goals, and (2) to develop a systematic strategy for collecting, aggregating, and reporting evaluation indicator data.

STRATEGY FOR ACHIEVING GOALS

In FY 1993. NASA initiated the key element of a strategy to enhance the evaluation of its education programs by contracting with National Research Council (NRC) to conduct a study and recommend appropriate evaluation indicators. The report from NRC was received by NASA in August 1994 and is now being implemented by convening education program managers along with experts from the professional evaluation community to develop data collection instruments. Additionally, more detailed evaluation studies of major program are to be conducted. These studies will conform to standards recommended by NSTC/CET and will be closely tied to management decisions regarding program continuation or modification.

MEASURES OF PERFORMANCE

In FY 1995, an evaluation indicator system, with corresponding data collection instruments and a database, will be operational across core NASA education programs. Two major evaluation studies will be implemented with results expected in FY 1996.

ACCOMPLISHMENTS AND PLANS

NASA has commissioned and received (in August 1994) a study by the National Academy of Sciences on evaluation indicators. Concomitantly, NASA has worked with the National Science Foundation to establish program evaluation standards. These indicators and standards are now being implemented in all of NASA's education programs. NASA's plans call for a revised database to collect all these data and specific instrumentation to be developed and implemented.

Minority University
Research and Education

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS — MINORITY UNIVERSITY RESEARCH AND EDI PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1994	FY 1995 (Thousands of Dollars)	FY 1996	page Number
Historically black colleges and universities	17.700	25.000	30.500	SAT 7.2-4
Other minority universities	7.000	14.400	20.000	SAT 7.2-9
Graduate student researchers program (Underrepresented minority and disabled focus)	3.400	3.400	3.600	SAT 7.2-13
Undergraduate student researchers program (Underrepresented minority and disabled focus)	3.100	3.100	3.200	SAT 7.2-16
Total	31.200	45.900	57.300	

Distribution of Program Amount bv Installation

Johnson Space Center	675	1.125	1.275
Kennedy Space Center	125	575	725
Marshall Space Flight Center	837	987	1.137
Stennis Space Center	134	344	494
Ames Research Center	75	425	575
Dryden Flight Research Center	--	200	350
Langley Research Center	2.266	2.416	2.566
Lewis Research Center	325	975	1.125
Goddard Space Flight Center	919	1.169	1.319
Jet Propulsion Laboratory	1.287	1.437	1.587
Headquarters	24.557	36.247	46.147
Total	31.200	45.900	57.300

ACADEMIC PROGRAMS — MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

PROGRAM GOALS

NASA has made a major commitment to being a leader in strengthening the research infrastructure capabilities of minority universities to compete for "mainstream" federal funding. The goal of the Minority University Research and Education program is to strengthen the research capabilities of Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs) primarily Hispanic-Serving Institutions (HSI's) and Tribal Colleges, and to develop a stronger and more diverse resource pool of scientific and technical talent from which NASA and the Nation will benefit.

STRATEGY FOR ACHIEVING GOALS

The goal of strengthening the research capabilities of minority institutions has been one of NASA's major goals for several years. The Congress and Executive Branch have established a clear record of commitment to increasing the involvement of minority institutions in federally-sponsored programs. One of the Administration's national education goals is to increase the number of women and minority students receiving graduate and undergraduate degrees in mathematics and science. The NASA Minority University Research and Education program seeks to form alliances between minority institutions. majority research institutions. state and local governments, elementary and secondary schools. industry and other Federal Research and Development programs.

The Minority University Research and Education program pursues these alliances through the aggressive implementation of research initiatives for the HBCU's and the OMU's (particularly the HSI's and the Tribal Colleges). and by supporting undergraduate and graduate student incentive programs at minority universities. The NASA Program Offices and Installations are directly involved in this strategy by providing technical assistance and long-term research programs to prepare and guide the transition of minority institutions, faculty and students into NASA's research and education competitive peer review processes. Ultimately, it is anticipated that these institutions, faculty and students will be prepared to compete successfully in NASA's mainstream research and employment processes. There is close collaboration with the NASA Education Programs to ensure that minority institutions and their elementary and secondary school partners, especially those with predominant enrollments of underrepresented minority students, are aware of and involved in the Agency's K-12 mathematics, science, and technology educational efforts.

NASA's outreach to minority institutions is accomplished primarily through research and training grants which focus on specific research disciplines relevant to NASA requirements in science and technology. These grants are used to support faculty and students at HBCUs and OMU's, thereby increasing the scientific and technological contributions from these institutions, and increasing the pool of underrepresented minorities in NASA-related science and engineering disciplines. The four primary categories of awards and their goals are:

- Minority Research Centers - to develop broad-based research in areas related to NASA's strategic enterprises. Support for the Research Centers is provided by the NASA program offices.

- Institutional Research Awards - to strengthen the research infrastructure of minority universities and to provide focus on NASA disciplines through a quality learning and research environment for underrepresented minority students and faculty members.

- Principal Investigator Awards - to increase diversity in the NASA-sponsored research community by providing "start-up" funds for underrepresented minority investigators at minority institutions.

- Math and Science Awards - to contribute to the Nation's mathematics, science, and technology goals by supporting and participating in partnerships led by minority institutions and involving state and local elementary and secondary schools, corporations, and community-based organizations that support and further the mathematics. science. and technology education of underrepresented minorities and individuals with disabilities.

The NASA Institutional Program Offices and other technically oriented program offices contribute to the success of the Minority University Research and Education program by selecting. funding and conducting research activities with minority universities. In FY 1994. the NASA Program Offices funded $17.7 million of research activities at minority colleges and universities. This funding level is expected to increase to $20.8 million in FY 1995 and to $24.3 million in FY 1996.

To encourage the development of talent at the undergraduate and graduate level, a special focus on Underrepresented Minority and Disabled Students was established within the NASA Graduate and Undergraduate Student Researchers program. This program identifies capable students at the undergraduate and graduate level pursuing degrees in science or engineering. These students receive tuition support, mentoring support and opportunities to spend their summers conducting research with principal investigators at their universities, NASA Installations. Federal laboratories or private industry.

BASIS OF FY 1996 BUDGET REQUIREMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Historically black colleges and universities	17.700	25,000	30,500

PROGRAM GOALS

The goal of NASA's Historically Black Colleges and Universities (HBCU) program is to strengthen the capacity of HBCUs to provide quality education; and to increase opportunities for HBCUs. their faculty and students to participate in and benefit from NASA's research and education programs.

STRATEGY FOR ACHIEVING GOALS

The HBCUs were involved in NASA's mission before man set foot on the Moon in 1969. In 1980, President Jimmy Carter signed Executive Order 12232 which established a Federal program "...to strengthen and expand the capacity of HBCUs to provide quality education." Executive Orders issued by Presidents Ronald Reagan and George Bush strengthened this program. NASA's current initiatives for the HBCUs are based upon two recent Executive Orders. Executive Order 12876. signed November 1.1993, mandates that agencies "...advance the development of human potential, to strengthen the capacity of HBCUs to participate in and benefit from federal programs...to achieve an increase in the participation by HBCUs in federal programs." Executive Order 12928. signed September 16, 1994. directs Federal agencies to promote procurement with "...Historically Black Colleges and Minority Institutions." NASA employs a comprehensive strategy to accomplish the HBCU program goals. This approach is carried out through awards in four areas:

1. Research Center Awards
2. Institutional Research Awards
3. Individual Principal Investigator Awards
4. Mathematics and Science Awards

The NASA HBCU Research Center Awards program was established in FY 1991 by the Office of Space Science and Applications: the Office of Aeronautics, the Office of Space Flight: and the Office of Equal Opportunity Programs. The goal of the HBCU Research Center program is to develop broad-based competitive research capability in areas related to space science and applications, advanced space technology, and advanced aeronautics technology, while expanding the Nation's base for aerospace research and development, and increasing the participation of the HBCU faculty and students in the Agency's research. Seven Research Centers were selected to receive 5-year research grant awards. These selections were based on the technical quality and

understanding of the proposed core research and its relevance to NASA: the strength and quality of the HBCU's existing undergraduate and graduate research programs: management and staffing of the research center: the university's commitment to the institutional long-term strategic commitment in the core research area: and university, government agency and industry partnerships.

The following institutions were selected as HBCU Research Centers:

University	Research Focus
Tuskegee University	Center for Food Production, Processing and Waste Management for Controlled Ecological Life Support Systems (CELSS)
Howard University	Center for the Study of Terrestrial and Extraterrestrial Atmospheres
Florida A&M University	Center for Nonlinear and Nonequilibrium Aeroscience
Clark Atlanta University	High Performance Polymers and Ceramics (HiPPAC) Center
North Carolina A&T State University	Center for Aerospace Research
Fisk University	Center for Photonic Materials and Devices
Hampton University	Center for Optical Physics

NASA's Institutional Research Awards (IRA) program is being expanded to include outreach to the HBCU's during FY 1995. The IRA program targets the HBCU's which do not receive significant NASA research funding and which offer graduate degree programs in engineering or science. The objectives of the IRA program are: to strengthen and improve core research areas of significance to the NASA mission: increase the number of underrepresented minorities who are U.S. citizens conducting space research and working in NASA-related disciplines: and, strengthen the research environment of eligible institutions and the capability of individuals by supporting the institutional infrastructure through the acquisition of research equipment: faculty research: underrepresented minority U.S. citizens who are undergraduate and graduate student researchers: and technology transfer to market place and minority communities. This year's IRA solicitation will call for research proposals that achieve routine full Internet usage at HBCU's conducting NASA-related research and education.

Principal Investigator Awards identify outstanding and promising engineering, physical and life science tenure-track underrepresented minority and disabled faculty early in their academic careers, who are capable of contributing to the Agency's research objectives, and who have limited past NASA research grant experience. The Principal Investigator awards provide faculty members with sufficient research support and exposure to the NASA peer review process to enable them to demonstrate creativity,

productivity, nd future promise in the transition toward achieving competitive awards in the Agency's mainstream research processes.

The HBCU Mathematics and Science Awards program focuses on strengthening the capacity of the HBCU's to provide excellence in mathematics, science, engineering, and technology (MSET) training while increasing the participation and achievement of underrepresented minorities and persons with disabilities in the MSET fields at all levels of education.

NASA has established Technical Review Committees to provide technical guidance and on-site reviews to the IRA and the Research Center award recipients in order to help them achieve their goals. NASA promotes collaboration between its HBCU-funded programs. the Installations and the Jet Propulsion Laboratory (JPL); and with entities outside of NASA. Institutions are encouraged to seek funding through NASA's traditional opportunities, as well as other government agencies and private sources. This is done in an effort to promote future sustainability. Research Centers, IRA's and Principal Investigator (PI's) awards require substantial undergraduate and graduate student involvement in research projects. The mathematics and science awards are normally managed by personnel at the NASA Installations and the JPL.

NASA Headquarters Program Offices, NASA Installations and the JPL support the HBCU program through direct funding. use of their facilities, and commitment of their personnel to serve on Technical Review Committees, and assist in other facets of program implementation. Numerous students and PI's from the HBCU's spend time on-site at the Installations and the JPL throughout the year.

MEASURES OF PERFORMANCE

Progress towards achieving the HBCU program goals is monitored through assessing the research involvement and productivity of faculty and students in NASA programs at HBCUs. In FY 1994, 124 faculty-level investigators were involved in NASA-related research work at the seven HBCU Research Centers, and 103 faculty researchers were involved in individual principal investigator research projects at HBCUs. During this same period, the HBCU Research Centers involved in their research work 96 graduate and 135 undergraduate U.S. citizen, underrepresented minority students, produced 140 refereed papers or book chapters. and gave 166 presentations at research conferences or seminars. Building on their FY 1992-FY 1993 NASA funding, the HBCU Research Centers secured $16.7 million in 1994 research funding from other sources, as compared to the $10.6 million invested by NASA in FY 1994. Service on NASA peer review and advisory panels is a key indicator of integration into the mainstream of NASA research. In FY 1994, four incidences of such service were reported by the HBCU Research Centers. Greater involvement will be sought in FY 1995.

Similar data for individual principal investigator awards is being compiled, but is not yet available. In FY 1995, the productivity represented by these indicators is expected to increase as the existing HBCU Research Centers reach maturity, and new HBCU Research Centers and Institutional Research Awards are established.

Re-college students are involved mainly through faculty, student and teacher preparation programs carried out by the HBCUs. In FY 1994. NASA outreach programs at seven HBCUs involved 2,264 underrepresented minority students in mathematics, science, engineering, and technology enhancement activities. In FY 1995, these numbers are expected to increase significantly as the Mathematics, Science and Technology Preparation and Curriculum Enhancement Awards (MASTAP) and Pre-College Awards for Excellence in Mathematics, Science, Engineering and Technology (PACE/MSET) projects are initiated at HBCUs.

ACCOMPLISHMENTS AND PLANS

In FY 1994. NASA provided support to 37 out of the 106 existing HBCUs. This funding included a total of 29 research projects and 20 training projects, with 12 of the HBCUs having both training and research projects.

NASA provided the third year of funding for seven HBCU Research Centers during FY 1994. As a result of satisfactory technical progress as determined by on-site reviews of all the HBCU Research Centers, and recommendations from the NASA Technical Review Committees to continue funding in FY 1995, these seven Research Centers will be sustained for a fourth year. During the fourth year of the 5-year award, a comprehensive technical review by technical peer reviewers external to NASA will be made of each Research Center. The results of the external review will be used by NASA to finalize the continuation process for the above Research Centers before the last year of their 5-year grant award. Additionally, in FY 1995, two new Research Centers will be selected as a result of a competitive peer review process conducted by internal NASA and external technical reviewers. All nine Research Centers will be sustained in FY 1996.

During FY 1995, the IRA program will be expanded to include the participation of the HBCUs. The focus of the FY 1995 awards will be on establishing three HBCU Network Resources and Training Sites (NRTS). These sites will be responsible for stimulating the use of the Internet as an integral part of minority institutions' interdisciplinary research and education capabilities. Additionally. the HBCU NRTS's will be required to assess the specific needs of institutions in their region. to provide network connectivity for the institutions in their region, and to provide a user resource center and network training for the HBCU faculty and students in their region. During FY 1996, these three IRA's will be sustained. and three new IRA awards will be competitively selected.

The awards to individual PI's at the HBCU's were slightly increased between FY 1994 and FY 1995 to a total of 117 awards. During FY 1996, the total awards to the PI's will increase to 138. with an average of $75,000 per award. Consistent with the Administration's FY 1996 research and development priorities. all research funded under the minority university program will continue to be primarily awarded through merit review with peer evaluation processes. For individual PI awards, an annual research announcement of opportunity. the Faculty Awards for Research (FAR) has been developed. Peer review is conducted by NASA Installations and the JPL technical personnel. Following the merit review, selections are made by NASA Headquarters Program Offices and the FAR recipients are awarded 3-year research grants. During FY 1995. six second-year HBCU FAR awards will be continued, and up to 10 new FAR recipients will be selected. Funding in FY 1996 will continue support to award recipients.

In support of the national mathematics and science education goals, NASA funds educational programs to support the preparation. persistence and participation of underrepresented minorities and individuals with disabilities in Agency-related

disciplines. Two competitive peer review processes have been established to identify and select the most productive projects in this area. These processes involve two different initiatives: the MASTAP and the PACE/MSET.

The MASTAP was initiated under NASA's Other Minority University program in FY 1994. The primary objective of MASTAP is to support institutions of higher education to increase the number and quality of underrepresented minority teachers well-prepared in science and mathematics. MASTAP is designed to increase the number and strengthen the technical skills and knowledge of underrepresented minority mathematics, science and technology pre-service teachers at the HBCU's who become state-certified to teach in middle and high schools that have substantial enrollments of underrepresented minorities: and to improve mathematics and science literacy among underrepresented minority pre-service and in-service teachers and middle and high school students. In FY 1995, the HBCU's will be able to submit proposals for the first time in response to NASA's program notice. Through the competitive peer review selection process, three institutions will be selected for awards in FY 1995. In FY 1996, NASA will sustain these three awards and competitively select three additional awards.

The PACE/MSET program will be initiated in FY 1995. The purpose of the program is to contribute to the national education goals by supporting research-based educational outreach projects that increase the number and strengthen the skills, knowledge and interest of underrepresented minority and disabled students in college preparatory mathematics, science and technology courses in public middle and high schools with substantial enrollments of minorities. During FY 1995, NASA will competitively select four awards at the HBCUs and continue to fund other ongoing efforts for a total of 33 pre-college projects. In FY 1996. NASA will use the PACE/MSET competitive review process to increase the number of projects at the HBCUs to 43.

In FY 1994, the NASA Program Offices contributed $11.3 million in support of research activities conducted primarily at the HBCU Research Centers. This funding is expected to increase to $12.8 million in FY 1995, and to $14.2 million in FY 1996.

BASIS OF FY 1996 BUDGET REQUIREMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Other minority universities	7,000	14.400	20,000

PROGRAM GOALS

The goal of NASA's Other Minority Universities (OMU) program is to increase the opportunities for Hispanics, Native Americans, Pacific Islanders, and people with disabilities to participate in and benefit from NASA's research and education programs.

STRATEGY FOR ACHIEVING GOALS

In the House and Senate Reports accompanying the FY 1985 VA-HUD-Independent Agencies Appropriations Act (P.L. 98-371), Congress established building relationships between NASA and minority institutions of higher education as a priority. Language included in both reports (House Report 98-803 and Senate Report 98-506) directed NASA to "...review institutions of higher learning having significant minority enrollments to find ways to build closer relations with such schools, meet NASA's research objectives and increase the number of individuals from underrepresented groups in the pool of graduate researchers...to build a closer relationship with institutions serving significant numbers of minorities...". To provide greater emphasis on this congressional mandate NASA established the OMU program in August 1991. Since that time, Residential Executive Orders and congressional reports have provided specific direction to the Agency to strengthen its research and education programs with other minority universities. Most recently, Executive Order 12900 (February 22, 1994) mandates that agencies increase Hispanic American participation in Federal education programs where Hispanic Americans currently are underserved, and Executive Order 12928 (September 16, 1994) directs Federal agencies to promote procurement with "...Historically Black Colleges and Minority Institutions." Congress has directed funding increases in FY 1994 and FY 1995 for the Hispanic-Serving Institutions (HSIs). Additionally, congressional direction was provided to NASA in the Conference report accompanying the FY 1995 VA-HUD-Independent Agencies Appropriations Act (P.L. 103-327) to establish NASA research centers at the HSI's.

NASA originally responded to the early Congressional and Executive Branch direction by formulating a five-year plan for the OMU program in FY 1991 to strengthen the Agency's research initiatives at other minority universities. This plan consists of three phases: (1) individual principal investigator research awards. (2) Institutional research awards and (3) teacher training and student programs focusing on NASA-related disciplines. and addressed all institutions with significant minority populations other than the Historically Black Colleges and Unversities (HBCUs). The OMU plan was expanded in FY 1993, when the NASA Administrator signed a plan to strengthen the Agency's relationships with HSI's. The direction received from the Congress and Executive Branch is reflected in the current program plan for the OMU.

NASA strategies for achieving the goals of the OMU program reflect those established in the HBCU program. However, because of the differences in the evolution of minority institutions and the particularities of Federal mandates for the HBCU's and Hispanic Americans, NASA's approach and implementation plan have been adjusted to take these factors into consideration. For example, the Federal mandate for Hispanic Americans directs Federal agencies to "...improve educational outcomes for Hispanic Americans participating in Federal education programs...". As a result, the Agency has placed greater emphasis on mathematics and science awards than on institutional research awards. The strategies for achieving goals under NASA's OMU program are identified below in priority order:

1. Mathematics and Science Awards
2. Individual Principal Investigator Awards
3. Institutional Research Awards: and
4. Research Center Awards

Competitive peer review processes have been established for each of the above areas. In 1991, unsolicited proposals were the primary mechanism used to fund mathematics and science awards. In 1994, the first minority university program, Mathematics, Science and Technology Teacher Preparation and Curriculum Enhancement Awards *(MASTAP))* competitive announcement of opportunity was issued for response by the OMU's. The Individual Principal Investigator (PI) awards program was established in 1992. under the Faculty Awards for Research Announcement of Opportunity. This was also the first competitive announcement of opportunity issued specifically to identify and attract faculty at the OMUs to NASA research. To enhance and build research capability in a core research area, NASA issued the first announcement of opportunity for the IRA's to the OMU's in 1994. The final strategy in NASA's plan to strengthen the research capability at the OMUs will be implemented in 1995. when the Agency selects four OMU Research Center Awards. This selection will be made through a competitive process.

MEASURES OF PERFORMANCE

In FY 1994, 44 faculty-level investigators were involved in NASA-related research work with the six IRAs, and 105 faculty researchers were involved in individual principal investigator research projects at the OMUs. During this same period. the IRA institutions involved 19 graduate and 29 undergraduate U.S. citizens, underrepresented minority students in these research activities.

Information on publications and leveraged funding for the IRAs is not yet available as they have yet to complete their first year of work, Data for individual principal investigator awards is being compiled. but is not yet available. In FY 1995, the productivity represented by these indicators is expected to substantially increase as the first IRAs move into their second year of funding, and new IRAs and the OMU Research Centers are established. Involvement in NASA conventional "mainstream" research processes is a key indicator of integration into the mainstream of NASA awards for recipients of IRA and principal investigator awards. Data on the level of involvement will be complied during FY 1995.

Pre-college students are involved mainly through faculty, student and teacher preparation programs carried out at OMUs. In FY 1994, NASA outreach programs at nine OMUs involved 4.225 underrepresented minority students in mathematics, science, engineering, and technology enhancement activities. In FY 1995, these numbers are expected to increase significantly as the first year of MASTAP projects are completed. and additional Mathematics, Science and Technology Teacher Preparation and Curriculum Enhancement Awards (MASTAP) and the Pre-college Awards for Excellence in Mathematics, Science, Engineering and Technology (PACE/MSET) projects are initiated.

ACCOMPLISHMENTS AND PLANS

In FY 1995, NASA will initiate a Research Center Program for the OMU's; four institutions will be competitively selected to receive awards. NASA will sustain these four Research Centers for a second year in FY 1996.

During FY 1994. six HSI's successfully competed to receive an IRA. These institutions are:

California State University at Los Angeles;
City College of New York
Florida International University;
New Mexico Highlands University;
University of Puerto Rico - Rio Piedras;
University of Texas at San Antonio.

In FY 1995. NASA will sustain these six awards and competitively select three additional OMU's for awards. The focus of the FY 1995 awards will be the design of an Internet network among the OMUs and other minority institutions for conducting network *training* and NASA-related research work. In FY 1996, NASA will sustain six third year and three second year IRA's to the HSIs and competitively select three additional OMUs for awards.

During FY 1994 PI awards, through the Faculty Awards for Research (FAR), at the OMUs totaled 40. In FY 1995. that number will be increased slightly to 52 awards. In FY 1996, total PI awards will increase to *88.* with an average of $75,000 per award. Growth is projected based on outreach to the PIs at the OMUs. The primary funding mechanism will be the FAR competitive peer review process.

To promote faculty and student development and teacher preparation, NASA funds two programs: the MASTAP and the PACE/MSET.

The primary objective of MASTAP is to support institutions of higher education to increase the number and quality of underrepresented minority teachers well-prepared in science and mathematics. MASTAP is designed to improve the quality of instruction in mathematics and science in our nation's elementary schools with significant minority enrollments. They are also to support development of diverse and exemplary research in the area of mathematics, science and technology teacher training. In FY 1994, NASA funded three MASTAP awards to the OMU's. In FY 1995, NASA will sustain these three awards and competitively select three additional awards at the OMU's. In FY 1996, NASA will sustain three third year and three second year awards, and competitively select three additional awards at $200,000 each.

The PACE/MSET program will be initiated in FY 1995. The purpose of the program is to contribute to the national education goals by supporting research-based educational outreach projects that increase the number and strengthen the skills, knowledge and interest of underrepresented minority and disabled students in college preparatory mathematics, science and technology courses in public middle and high schools with substantial enrollments of minorities. During FY 1995, NASA will competitively select four awards at the OMU's for $100,000 each and continue to fund other ongoing efforts for a total of 35 pre-college projects. In FY 1996, NASA will use the PACE competitive review process to increase the number of projects at the OMU's to 45.

In FY 1994, the NASA Program Offices contributed $6.4 million in support of research activities conducted at the OMU. This funding is expected to increase to $8.0 million in FY 1995, and to $10.1 million in FY 1996.

BASIS OF FY 1996 BUDGET REQUIREMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Graduate student researchers program (Underrepresented minority and disabled focus).....	3,400	3,400	3,600

PROGRAM GOALS

The goal of the Graduate Student Researchers program within the Office of Equal Opportunity Program (OEOP) is to positively affect the number of underrepresented minorities and persons with disabilities receiving graduate degrees in NASA-related fields, particularly those students attending minority institutions (MIs). The desired outcome for participants include employment with NASA or aerospace industries. as science and engineering faculty researchers, mathematics and science pre-college teachers or entrepreneurs.

STRATEGY FOR ACHIEVING GOALS

The Graduate Student Researchers program (Underrepresented Minority and Disabled Focus) (GSRP/UMDF) was initiated to respond to direction from Congress in the House and Senate Reports accompanying the FY 1985 VA-HUD-Independent Agencies Appropriation Act (P.L. 98-371) to "...look at those institutions of higher learning having significant minority enrollments in an effort to find ways to build closer relations with such schools, meet NASA's research objectives. and increase the number of individuals from underrepresented groups in the pool of graduate researchers." In the House Committee Report (103-555) accompanying the FY 1995 VA-HUD-Independent Agencies Appropriations Act (P.L. 103-327). language is included encouraging NASA to "...develop and increase Ph.D. graduate fellowship programs at HBCUs and HSIs offering Ph.D.s in NASA-related discipline areas: and increase scholarship and graduate fellowship activities for underrepresented minority students and individuals with disabilities."

The OEOP supports graduate students through several programs. The largest of these is the GSRP (UMDF), which began in 1987. The OEOP works in close collaboration with the NASA Installations and the Jet Propulsion Laboratory (JPL) to select Masters and Ph.D. candidates for the program. Evaluations are based on the applicants' research proposals and/or plans of study. The Installations and the JPL assign technical monitors and collaborate with the student and his/her advisor on research related to NASA's mission. NASA requires active participation from the institutions. which provide student support services, faculty mentors. guidance on research. tuition support, and administrative support. NASA also works in conjunction with two other national programs to support graduate students. One, the American Society for Engineering Education (ASEE) Helen T. Carr Fellowship program, provides fellowships for African-Americans pursuing Ph.D.s in engineering. Upon completion of the doctoral requirements. a fellow is committed to teach at one of the HBCU's engineering schools. Another program, the National Physical Science Consortium (NPSC) Fellowship, provides up to six years of support to underrepresented minorities pursuing Ph.D.s in the physical sciences. Currently. the majority of students in these programs attend major research institutions. The OEOP. working

with the Installations and the JPL, will expand recruitment activities for all of its graduate programs to include juniors and seniors at minority institutions to encourage their consideration and preparation for graduate-level programs. As a result of these efforts, the OEOP will increase the selection of students at minority institutions to a minimum of ten per year, thereby increasing support to minority institutions through participation in graduate programs.

MEASURES OF PERFORMANCE

Progress towards achieving the OEOP GSRP goals is monitored through assessing the numbers of U.S. citizen, underrepresented minority graduate students involved in NASA-related research and studies through the graduate program. While the total numbers of such students is projected to remain roughly constant from FY 1994 through FY 1996, funding will shift towards a greater emphasis on supporting students at minority universities, as shown below:

	HBCU	Hispanic Serving Institutions	Other universities
FY 1994	0	20	146
FY 1995	15	30	109
FY 1996	33	35	95

Ultimate program success is measured by the number of students completing graduate degrees and entering employment in scientific and technological fields. This data is being collected, but is not yet available.

AC AND PLANS

In FY 1994. the eighth year of the program, an additional 49 underrepresented minority students were selected for a total of 147 participants in the GSRP (UMDF). This total included 41 black males, 24 black females, 47 Hispanic males, 16 Hispanic females, 4 American Indian males, 3 American Indian females, 5 Pacific Islander males, 3 Pacific Islander females, and 4 non-minority disabled males. In addition. 9 students were supported through the ASEE Helen T. Carr Fellowship program and 10 through the NPSC Fellowship. In both FY 1995 and FY 1996. 50 new students will be selected to receive support through these programs.

In FY 1994, $462,000 (14%) of the total funding granted to institutions under this program was granted to minority institutions. During FY 1995. the program will focus more heavily on minority institutions. with plans to award them $1.0 million (29%) of the total funding granted. The plan for FY 1996 is to award $1.5 million (42%) of the $3.6 million budgeted for this program to minority institutions.

In FY 1995. a panel of outside experts was convened to evaluate this program and recommend changes. Based on their Anal report, NASA anticipates significant restructuring of the program. beginning in FY 1996. Projected changes include increasing

recruitment of Masters level candidates, aggressively identifying and working with minority institutions offering graduate degrees in NASA-related disciplines, and limiting the number of institutions allowed to participate in the program. Beginning in FY 1995, at least five students attending the HBCUs and five attending the HSIs will be selected into the program each year.

BASIS OF FY 1996 BUDGET REQUIREMENT

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Undergraduate student researchers program Underrepresented minority and disabled focus).....	3,100	3,100	3,200

M GOALS

The goal of the Office of Equal Opportunity's undergraduate program is to increase the presence of underrepresented minority and disabled students in fields of science, mathematics, engineering, and computer science compatible with NASA's mission. The desired outcomes for participants include entry into graduate programs: employment with NASA or aerospace industries, as science and engineering faculty researchers, or as mathematics and science pre-college teachers.

STRATEGY FOR ACHIEVING I

NASA's undergraduate program is designed to address one of the President's national education goals: to increase the number of minority students receiving undergraduate and graduate degrees in mathematics and science. This program, started in FY 1991, identifies high school senior and continuing first year underrepresented minority students majoring in science, engineering, mathematics or computer science and awards them scholarships through universities with proven records of recruiting, retaining and graduating underrepresented minorities and persons with disabilities in fields of science, engineering, mathematics and computer science. This program continues to select approximately 75 new students each year. The students receive tuition support: are monitored. tutored and nurtured: and spend their summers conducting research with principal investigators at their universities, NASA Installations, Federal laboratories or private industry. The NASA Installations and the Jet Propulsion Laboratory (JPL) annually review applications to the program, identify students for selection, and provide hands-on research experiences and mentors for those students. NASA requires active participation from the institutions, which provide student support services. faculty mentors, research experiences, additional tuition support as needed, and administrative support.

MEASURES OF PERFORMANCE

Progress towards achieving the Undergraduate Student Research Program (USRP) goals is monitored through assessing the numbers of U.S. citizen, underrepresented minority undergraduate students involved in NASA-related research and studies through the USRP program. While the total numbers of such students is projected to remain roughly constant from FY 1994 through FY 1996. funding will shift towards a greater emphasis on supporting students at minority universities, as shown below:

	HBCU	Hispanic Serving Institutions	Native American/ Disabilities Serving	Other Universities
FY 1994	54	54	13	127
FY 1995	66	66	14	108
FY 1996	78	78	16	84

Ultimate program success is measured by the retention rate, number of students entering graduate programs. and number of students employed in scientific and technological fields. The retention rates since program inception in FY 1991 have been 84.6%, 82.5%. and 91.67% for the cohorts beginning in FY 1991. FY 1992. and FY 1993, respectively. Data on graduation and career plans will be collected in FY 1995 as the first cohort graduates from college.

ACCOMPLISHMENTS AND PLANS

In FY 1994, the fourth year of the program, an additional 56 underrepresented minority students were selected for a total of 247 participating in the program. This total included 124 African-Americans, 103 Hispanics, 9 Native Americans, 3 Pacific Islanders. and 8 students with disabilities. FY 1995 will see the first class of graduates; the projected graduation rate for the program is 83%. based on the retention rate of the initial class of students. The pipeline of undergraduate minority students majoring in the physical and Me sciences and engineering coming from this program is expected to substantially and positively impact NASA's and the aerospace industry's hiring needs. Even more important. these students are being targeted for graduate level studies and research careers in the fields of science and engineering. The USRP (UMDF) will serve as a feeder to the GSRP (UMDF), in particular considering the relationships the students develop with the NASA Installations and the JPL as a result of participating in the USRP.

In FY 1994, $1.4 million (45%) of the $3.1 million awarded under this program was given to minority institutions (MIs). During FY 1995, the program will focus more heavily on minority institutions, with plans to award them $1.7 million (55%) of the $3.1 million granted. The plan for FY 1996 is to award $2.0 million (63%) of the $3.2 million budgeted for the program to MIs.

The graduating class each year will be replaced by new selections (approximately 75 per year), thereby keeping the number of participants fairly constant over the next several years.

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