National Aeronautics and
Space Administration

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Budget Estimates

Fiscal Year 1997

Volume I

Agency Summary

Human Space Flight

Science, Aeronautics and Technology

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Agency Summary

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1997 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 is 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.

PLANS AND ACCOMPLISHMENTS

The NASA budget request for FY 1997 is reflected in four appropriations:

Human Space Flight - providing funding for the Space Station and Space Shuttle programs, including 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 facilities construction activities to preserve NASA's core infrastructure:

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

NASA has been at the forefront of the Administration's efforts to reshape the federal government, to make it smaller, cut costs, and be more responsive to the ultimate customer, the taxpayer. The FY 1997 budget request meets the challenge included in the FY 1996 budget of achieving reductions of $4 billion for the years FY 1997-FY 2000. This brings the total budget savings achieved by NASA to $40 billion since the FY 1993 budget. During 1995. the agency undertook a total review of its activities. The Zero Base Review focused on ways to streamline NASA's operations, reduce overlap. and return NASA to being an R&D agency. The recommendations from the Zero Base Review team, which are being put into place across the agency, met the overarching challenge of the undertaking - to maintain NASA's position as a premier research and development agency, where safety will be equal or better, science and technology content and results will be equal or better and more relevant, and there will be an increase in programs with a decrease in cycle time. Real infrastructure changes have been taken to meet the budget runout targets.

- Plans are underway to implement a single Shuttle contractor in FY 1997 at the Kennedy Space Center.
- A reduction in planned civil service staffing levels by FY 1999 will bring the NASA workforce to its lowest level since the early 1960s.
- Reductions in support contractors are being implemented across NASA.
- Facilities are being closed based on objective analysis of how requirements can be consolidated and overlap eliminated.

The Zero Base Review identifled a unique agency-wide area of technical competence and a unique mission for each of the NASA field centers. These Center Missions and Centers of Excellence map directly to NASA's Strategic Enterprises and provide a direct relationship to the way each Center supports NASA's goals. In 1996. NASA will transition its management practices to reflect this approach. The leaders of each Enterprise at Headquarters will provide the strategy for each area consistent with the NASA Strategic Plan. The responsibility and accountability for program implementation will be at the NASA field centers.

The NASA budget request for FY 1997 continues the commitment by the President to invest in the future In the FY 1996 budget, the President set forth a strategy for investing in science and technology. This strategy reached across the federal government, encompassing goals which emphasize world leadership in science, mathematics and engineering, economic growth, improved environmental quality. and harnessing information technology.

The programs included in the New Millennium Initiative are underway, and funding is continued in the FY 1997 budget request. These programs experiment with new innovative management and procurement practices, promote smaller affordable missions and enforce strict adherence to performance criteria and a cost cap.

- The Discovery program reflects NASA's commitment to ensuring a continuous stream of new planetary science data and more frequent access to space. The first Discovery mission, the Near Earth Asteroid Rendezvous (NEAR) mission, was launched in February 1996. The second Discovery mission, the Mars Pathfinder, is scheduled for launch in late 1996.
- The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. The first mission, the Mars Surveyor mission, is planned for late 1996.
- Two missions, Lewis and Clark, are under development as part of the Small Spacecraft Technology Initiative. The major goal of this program is to demonstrate how to reduce the cost and development time of space missions for science and commercial applications. Launch of these missions is planned for mid-1996.
- The New Millennium Spacecraft program is an aggressive technology development and demonstration program underway that is designed to precipitate a revolution in the design, development and implementation of science spacecraft and instruments. This program involved very close cooperation between the Space Science, Mission to Planet Earth and Space Access and Technology program offices at NASA, in order to highlight both the key scientific challenges to be addressed as well as the key technology areas to address these challenges.
- The Earth System Source Pathfinder (ESSP) is a science-driven program intended to identify and develop small satellite missions to accomplish scientific objectives in response to national and international research priorities not addressed by current programs.

In order to achieve significant savings in the cost of space missions, the cost of going to orbit must be reduced by orders of magnitude. The Reusable Launch Vehicle program is addressing, in partnership with the private sector, the new and innovative technologies that are needed to meet the challenges and lower the costs of future space missions. 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.

NASA will participate as part of a governmentwide effort to upfront fund fixed assets and similar procurements. Upfront funding will strengthen budget planning, improve management accountability and flexibility, and enhance opportunities for cost savings. Upfront funding requests for FY 1997 are consolidated in a governmentwide account and are not shown in the NASA budget totals presented in this document. FY 1997 is considered a transition year to upfront funding with plans to include other NASA programs by FY 1998. For FY 1997, NASA has selected two activities that will greatly benefit from this improved budgeting: five missions under the New Millennium Initiative (NMI) and the Tracking and Data Relay Satellite (TDRS) replenishment.

NASA's ability to inspire and expand the horizons of present and future generations rests on the success of these efforts to maintain this nation's leadership in space within the reality of the fiscal constraints facing the federal budget.

NASA continues to be a leader in responding to the challenge of reducing the federal deficit and the goals of the National Performance Review. Over the past several years, NASA has undergone a thorough scrutiny of its mission, organization and activities. The Federal Laboratory Review, conducted by the National Science and Technology Council during 1995, reviewed the activities and functions of the Department of Defense, Department of Energy and NASA, to identify areas where overlap occurred and consolidation might be pursued. Their report endorsed the organization and activities of the NASA field centers. The Zero

Base Review. which involved a difficult introspective examination of NASA's activities and workforce, resulted in recommendations which are being implemented at every NASA field center, including Headquarters. This includes an updated NASA Streamlining Plan, which will reduce the NASA civil service workforce to 17,500 by 1999. This will be the lowest level of NASA civil servants since the early 1960s. 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 regularly reviews 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. The International Space Station is the culmination of the redesign work begun in FY 1993 to reduce program costs while still providing significant research capabilities. The program is led by a single contractor, Boeing, which has total development and integration responsibilities. The previous prime contractors. McDonnell Douglas, Rocketdyne, and Boeing Huntsville. are serving as first tier subcontractors to Boeing. A streamlined 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.

During the past year, the Space Station program has focused on transforming the detailed drawings of the International Space Station into flight hardware. production of flight hardware continued in earnest during FY 1995. Boeing completed the primary structure for the node structuxal test article (STA), node 1 and U.S. laboratory; rack structures assemblies, the common module mid-cylinder, and laboratory panels; and delivered the first two international standard payload racks (ISPR). Rocketdyne produced hardware includes several elements of the solar power module including the solar array mast, the radiator panel, solar array panels, the beta gimbal assembly, and the pump flow and control subassembly. McDonnell Douglas has assembled the pressurized *mating* adapter mockup, S0 truss segment and and S1 truss segment mockups, and the node structural test article detailed parts and subassembly. FY 1996 will see continued qualification testing, and manufacture of flight hardware as the program readies for First Element Launch (FEL) in November of FY 1997. International efforts will continue with closure of the NASA/Russian Space Agency Memorandum of Understanding on Space Station and renegotiation of MOUs with the European Space Agency (ESA), Japan, and Canada to reflect Russian participation. The ESA Ministerial Council will meet to finalize ESA participation in Station and all partners continue development of flight hardware. The Columbus orbital facility will undergo its Preliminary Design Review, the Japanese experimental module (JEM) will undergo Critical Design Review #1 and the Space Station remote manipulator system (SSRMS) will finish final integration. During FY 1997. the major program focus will be manufacturing and testing fllght hardware to support FEL in November of 1997 and subsequent launches throughout early 1998. Major preparation will be made in support of the FGB. node 1, truss segments. the U.S. laboratory, and the subsystems to support these elements. The international partners will continue development of flight hardware with the FGB flight article assembly completion and delivery to Baikanour, the start of the SSRMS performance test, and the JEM CDR 2. 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 MCC 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.

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 safely. including modifications to the Main Engine and the Orbiter. 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. Since FY 1992, the Shuttle program has undergone extensive restructuring, yielding a 24% budget reduction through FY 1995. This was accomplished primarily through reductions in flight rate. program content, contract consolidation and restructuring, and the accomplishment of continuous improvement efficiencies. During FY 1995. the Shuttle program conducted an extensive internal program review, which entailed a review of design and flight requirements and roles and missions, given the Shuttle's mature operational state. The reductions which resulted from that review are reflected in this budget request. In addition, transition to a consolidation of Space Shuttle operations contracts into a single prime contractual arrangement is underway. It is expected that this consolidation will achieve the challenge of finding additional cost savings in the outyears. These savings have been incorporated into NASA's budget planning.

In 1995, an American astronaut spent over three months on the Russian Space Station Mir, an important first step in the U.S.-Russian cooperative space program. In July 1995. the Shuttle docked with the Mir, delivering two Russian cosmonauts to the Mir, and returning one Amerlcan astronaut and two cosmonauts to the Shuttle. During the mission, a number of joint scientific experiments were performed using Mir and Space Shuttle-Spacelab equipment. Currently, nine 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. In FY 1996 and in FY 1997, American astronauts will spend 12 months aboard the Mir conducting research. U.S. - Russian cooperation in space and aeronautics extends across the NASA programs.

The Space Shuttle continues to provide its unique capabilities. In FY 1996, eight missions are planned. including three missions to the Mir Space Station. Seven missions are planned for FY 1997. including three missions to the Mir Space Station. Spacelab nights focusing on life sciences and materials sciences will be conducted during FY 1996 and FY 1997 in preparation for operations using the International Space Station.

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 life exists elsewhere. The

Space Science program has been restructured in the FY 1997 budget to consolidate the Physics and Astronomy and Planetary Exploration budget line items. This new structure will allow for simplicity in defining the enterprise and in making budget trade-offs between various space science disciplines. It reflects the organization of the consolidated Ofnce of Space Science and has no impact on programs.

The Space Science program 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 Near Earth Asteroid Rendezvous (NEAR) mission and the Mars Pathfinder continue, with NEAR launched successfully in February 1996 and Mars Pathfinder's launch scheduled for December 1996, both on Delta 11 launch vehicles. A Discovery mission development cost (phase C/D through launch plus 30 days) must be less than $150 million (FY 1992 dollars) and the mission must be launched 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. The Mars Surveyor *Program*, initiated in FY 1995 continues. Mars Surveyor is a series of small missions designed to resume the detailed exploration of Mars following the loss of the Mars Observer mission in 1993. The first spacecraft, Mars Global Surveyor. utilizes spare Mars Observer hardware and will be launched in November 1996, with subsequent missions to be launched at two year intervals.

Funding is requested to continue the New Millennium Program, which will advance state of the art in spacecraft technologies to enable more frequent, less costly missions on smaller spacecraft. This program is addressing key technology advancements -- including communications, navigation and attitude control, power. propulsion, avionics. instrumentation, rover technologies, operations and ground control. 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. This program involves close cooperation between the Office of Space Science, the Office of Mission to Planet Earth, and the Office of Space Access and Technology to ensure that technologies and missions are developed in a concurrent engineering mode, with strict attention paid to the contributions and impacts each technology contributes at the spacecraft systems and mission level. Funding is included to support the development of the first two demonstration missions selected in FY 1996.

Funding in FY 1996 and FY 1997 supports an aggressive Anal definition and preliminary design of the Thermosphere. Ionosphere, Mesosphere Energetics and Dynamics (TIMED) mission. The Anal commitment to proceed on the proposed mission will be made by the Program Management Council after an evaluation of TIMED's readiness to move into the Anal development phase. This evaluation will consider the technical readiness of the project as well as funding availability within the Space Science budget

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 the Gravity Probe-B mission and for Explorer missions. which conduct investigations of an exploratory or survey nature, as well as for a number of instruments and payloads to be used on international satellites or on Spacelab missions. Funding is also included to continue definition activities on the Stratospheric Observatory for Infrared Astronomy (SOFIA), a cooperative program with Germany that will replace the aging

Kuiper Airborne Observatory (KAO), and to continue definition of a Space Infrared Telescope Facility to complement the Hubble Space Telescope (HST). Together, these programs will launch a new era in infrared astronomy. Once definition studies are complete on these missions, the proposed programs will be evaluated by the Program Management Council for their readiness to move into the development phase. This evaluation will consider the technical readiness of the project as well as funding availability within the Space Science budget

Results from the refurbished the HST continued to dominate the world of astronomy during 1994. The results from Hubble continue to touch on some of the most fundamental astronomical questions of the 20th century. including the existence of black holes and the age of the universe. 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 the second servicing mission, scheduled for flight in 1997. Funding is included to continue development of the Advanced Camera for flight in 1999. Early results from initial data received from the Galileo Probe encounter with Jupiter are challenging scientists to reexamine long-held theories on the environment of this largest planet in our solar system. Funding to continue mission operations and data analysis activities is included.

Life and Microgravity Sciences and Applications

The Life and Microgravity Sciences and Applications program uses the space environment to understand the response of biological and materials systems to weightlessness. Flight opportunities aboard the Space Shuttle in FY 1995 provided a rich preview of research work that will be conducted on the International Space Station. In Microgravity Sciences. the second International Microgravity Laboratory flight (IML-2) was flown, focusing on materials science, fluid physics and biotechnology. The extended stay time of astronauts aboard the Russian Mir Space Station is providing the opportunity to accomplish a wide range of research using both U S. and Russian research hardware. These research activities will continue during FY 1996 and FY 1997 as U.S. astronauts continue their visits to the Mir. Three joint Russian/U.S. flights are planned for FY 1996, and three flights are planned for FY 1997. In addition to the Mir missions, 4 major Spacelab flights supporting both life sciences and microgravity research will be conducted in FY 1996-97. The US. Microgravity Laboratory-2 flew early in FY 1996, and will be followed by the U.S. Microgravity Payload-3 mission. the Life and Microgravity Sciences (LMS) mission, and the Microgravity Sciences Laboratory-1 mission. Preparations continue through FY 1997 for the transition to the International Space Station. In FY 1997, seven major payload facilities will be in definition or development for flights beginning in FY 1998.

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-tern contributions to understanding the Earth as an integrated system as well as environmental issues, such as global warming and ozone depletion. 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 for the continued development of the Landsat-7 spacecraft, instruments and ground system is included. Landsat-7 is scheduled to launch in 1998. After launch and check out, the National Oceanic and Atmospheric Administration (NOAA) will be responsible for Landsat-7 operations.

During 1995. NASA conducted a comprehensive review of EOS to reshape mission planning to substantially reduce EOS life-cycle costs while preserving the basic measurement set; to provide for technology infusion for the second and third EOS series: to provide new science opportunities through small satellites: and to adjust program management to an evolutionary approach. The EOS program will benefit greatly from technology infusion from the New Millennium program. in the form of new instruments, smaller spacecraft designs. and autonomous operations. The program has also introduced an Innovative project to procure data sets directly from private industry. The purchase of data sets instead of spacecraft hardware will represent a significant and growing new means for conducting Earth observing science.

Aeronautical Research and Technology

The Aeronautics 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 1997 program continues important investments required to pursue the high leverage technologies required to support both the subsonic and high-speed civil transport economic viability. The Advanced Subsonic Transport (AST) program continues to make substantial progress in the development of high-risk, high-payoff technologies for a new generation of environmentally compatible. economic subsonic aircraft and a safe, highly productive global air transportation system. Funding for the continuation of all program elements is included through FY 1997. Phase I of the High Speed Research (HSR) program was completed in FY 1995. This six year effort, begun in FY 1990, addressed environmental barrier issues, as well as design and performance characteristics critical to an environmentally acceptable high speed civil transport. 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. Funding for Phase 11 of the HSR program is continued. 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 Administration has determined that construction of a new wind tunnel, at a cost of $1.2 billion, is not economically feasible at this time. Improvements to aircraft design and test capabilities are still highly important: effective means to achieve these objectives will remain a priority.

Space Access and Technology

The Space Access and Technology program leads NASA's efforts to develop advanced space technologies critical to the economic, scientific, and technological competitiveness of the U.S. U.S. industrial preeminence is promoted 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. Lower mission costs also require development of advanced spacecraft systems to reduce the costs of building and operating spacecraft, while meeting the demanding science requirements of the mission. NASA 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, being pursued in close partnership with U.S. industry and the Department of Defense, includes systems engineering and concept analysis, ground based technology development, and a series of flight demonstrators - the DC-XA, the X-34 Small Reusable Demonstrator 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

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, OMB and OSTP, and reviewed by an outside panel of experts. The program's progress toward meeting the criteria will be reviewed annually. The release of funds identifled 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's Spacecraft Systems program is working with the space science community to develop technology products for future planetary, astrophysics, astronomy, Earth observing and human exploration spacecraft systems. These products will dramatically reduce costs and increase performance to enable new and more flexible missions. The program plans to accomplish its tasks by focusing technology development on key objectives: (1)reduce the mass and increase the efficiency of spacecraft subsystems and systems to enable use of smaller launch vehicles: (2) increase on-board and ground system autonomy to reduce overall mission operations cost: and (3)exploit micro-fabrication technology to develop miniaturized components and instruments with equal or better performance than current components and instruments.

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 the agency 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, programs are supported in the areas of communications spacecraft technology, robotics. remote sensing and, 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.

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, primarily Hispanic-serving institutions and Tribal Colleges. to participate in and benefit from NASA's research and education programs. The FY 1997 budget request for the Minority University Research program continues this commitment through funding for initiatives which are underway.

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.

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 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 Communications 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 Satellite (TDRS) System, the ground terminals at White Sands, New Mexico, and the NASA Control Center at the Goddard Space Flight Center. 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. The TDRS Replacement spacecraft, F-7, was launched by the Shuttle in July 1995. and has been successfully checked out in geosynchronous orbit. In FY 1995, a contract for the development of three replenishment TDRSS spacecraft was awarded to the Hughes Space and Communications Company, with availability planned to begin in 1999. The modernization of the original White Sands Ground Terminal, Cacique, will be completed in 1996, and returned to operational service. With its twin, Danzante (Second TDRS Ground Terminal), these ground terminals will provide fail-safe operations of the Space Network and its TDRS spacecraft. Planning is underway to consolidate and streamline major support contract services in order to optimize space operations. In FY 1996, as an interim measure, a voluntary contractor partnership is envisioned between the major incumbents. Allied Signal Technical Services Corporation and Computer Sciences Corporation. A new contract is required in FY 1998. At that time, transition to a performance-based space operations contract, or possibility a privatized or commercialized operation will be decided.

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's workforce in the year 2000 will be focused on the crucial research and development that will keep this country even with the incredible pace at which the global economy is changing. The largest segment of savings resulting from the Zero Base Review is achieved from reductions in planned levels of civil service staffing and support. Current planning supports a civil service workforce of 17,500 by FY 1999. This workforce will be technically outstanding to meet the challenges of NASA's diverse and highly technical programs, and will be engaged in activities which keep NASA at the forefront of cutting edge technology development.

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 existing 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 1997 BUDGET SUMMARY
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1995	1996	1997
HUMAN SPACE FLIGHT	**5,514.9**	**5,456.6**	**5,362.9**
SPACE STATION	1,889.6	1,863.6	1,802.0
US/RUSSIAN COOPERATIVE PROGRAM	150.1	129.2	138.2
SPACE SHUTTLE	3,155.1	3,148.8	3,150.9
PAYLOAD AND UTILIZATION OPERATIONS	320.1	315.0	271.8
SCIENCE, AERONAUTICS AND TECHNOLOGY	**5,917.4**	**5,845.9**	**5,862.1**
SPACE SCIENCE	2,032.6	2,032.6	1,857.3
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	467.4	488.5	498.5
MISSION TO PLANET EARTH	1,344.1	1,289.4	1,402.1
AERONAUTICAL RESEARCH AND TECHNOLOGY	845.5	845.9	857.8
NATIONAL AERONAUTICAL FACILITIES	35.0	--	--
SPACE ACCESS AND TECHNOLOGY	605.4	641.3	725.0
MISSION COMMUNICATION SERVICES	481.2	441.3	420.6
ACADEMIC PROGRAMS	106.2	106.9	100.8
MISSION SUPPORT	**2,548.3**	**2,502.2**	**2,562.2**
SAFETY, RELIABILITY AND QUALITY ASSURANCE	38.7	37.6	36.7
SPACE COMMUNICATION SERVICES	225.0	269.4	291.4
RESEARCH AND PROGRAM MANAGEMENT	2,149.6	2,052.8	2,078.8
CONSTRUCTION OF FACILITIES	135.0	142.4	155.3
INSPECTOR GENERAL	**15.8**	**16.0**	**17.0**
TOTAL BUDGET AUTHORITY	**13,996.4**	**13,820.7**	**13,804.2**
TOTAL OUTLAYS	**13,377.3**	**14,190.0**	**13,697.8**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1997 ESTIMATES
SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS

	TOTAL	Human Space Flight	Science, Aero & Technology	Mission support	Inspector General	Nat'l Aero Facilities
FISCAL YEAR 1995						
VA-HUD-INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1995 (P.L. 103-327)	14,404.7	5,514.9	5,901.2	2,572.6	16.0	400.0
DEPARTMENT OF DEFENSE EMERGENCY SUPPLEMENTAL APPROPRIATION, FY 1995 (P.L. 104-6) AMENDING P.L. 103-327	-365.0		35.0			-400.0
DEPARTMENT OF DEFENSE APPROPRIATIONS ACT, FY 1995 (P.L. 103-335)	60.0		60.0			
LESS FINAL TRANSFER FROM DOD FOR LANDSAT	-10.0		-10.0			
FY 1995 EMERGENCY SUPPLEMENTAL APPROPRIATIONS ACT (P.L. 104-19)	-92.0		-52.7	-39.3		
LAPSE OF FY 1995 UNOBLIGATED FUNDS	-1.3			-1.1	-0.2	
TOTAL FY 1995 BUDGET PLAN	**13,996.4**	**5,514.9**	**5,933.5**	**2,532.2**	**15.8**	**0.0**
FISCAL YEAR 1996						
VA-HUD-INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1996 (H.R. 2099) AS PASSED BY CONGRESS, DIRECTION INCLUDED IN CONFERENCE REPORT H.R. 104-384						
TOTAL FY 1996 BUDGET PLAN	**13,820.7**	**5,456.6**	**5,845.9**	**2,502.2**	**16.0**	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1997 ESTIMATES

SUMMARY OF RESOURCES REQUIREMENTS

Distribution of Proaram Amount bv Installation
(Thousands of Dollars)

	Total			Human Space Flight			Science, Aeronautics and Technology			Mission Support		
	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
Johnson Space Center	3,327,157	3,427,943	3,194,974	2,804,237	2,898,300	2,701,600	146,897	162,728	133,284	376,023	366,915	360,090
Kennedy Space Center	1,332,386	1,233,392	1,250,964	1,024,560	948,500	952,800	50,462	36,361	38,833	257,364	248,531	259,331
Marshall Space Flight Center	2,528,753	2,494,656	2,658,840	1,537,508	1,484,300	1,570,300	612,523	663,874	735,648	378,722	346,482	352,892
Stennis Space Center	107,010	108,068	109,771	51,200	47,000	52,600	20,015	22,523	21,936	35,795	38,545	35,235
Ames Research Center	631,097	598,949	617,868	0	0	0	456,122	425,014	443,063	174,975	173,935	174,805
Dryden Flight Research Center	117,554	123,094	159,212	6,100	5,600	5,400	62,119	76,174	93,372	49,335	41,320	60,440
Langley Research Center	606,124	584,474	589,627	1,521	300	600	376,798	376,533	372,121	227,805	207,641	216,906
Lewis Research Center	736,845	792,903	772,218	17,500	7,000	5,000	497,670	562,140	549,200	221,675	223,763	218,018
Goddard Space Flight Center	2,630,327	2,414,216	2,535,617	12,050	8,000	7,400	2,123,862	1,875,556	1,962,362	494,415	530,660	565,855
Jet Propulsion Laboratory	945,234	917,648	819,762	15	200	0	923,045	890,475	791,059	22,174	26,973	28,703
Headquarters	997,388	1,087,887	1,051,502	60,209	57,400	67,200	647,887	754,522	721,222	289,292	275,965	263,080
Undistributed:												
Construction of Facilities:												
Various locations	10,725	11,470	8,145	0	0	0	0	0	0	10,725	11,470	8,145
Facility Planning and Design	10,000	10,000	18,700	0	0	0	0	0	0	10,000	10,000	18,700
Inspector General	15,800	16,000	17,000									
TOTAL NASA	13,996,400	13,820,700	13,804,200	5,514,900	5,456,600	5,362,900	5,917,400	5,845,900	5,862,100	2,548,300	2,502,200	2,562,200

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

ADMINISTRATIVE PROVISIONS

[(INCLUDING TRANSFER OF FUNDS)]

Notwithstanding the limitation on the availability of funds appropriated for "Human space flight", "Science, aeronautics and technology", or "Mission support" by this appropriations Act, when (1) any activity has been initiated by the incurrence of obligations for construction of facilities as authorized by law, or (2) amounts are provided for fill-finding for the New Millennium Initiative, and for the Tracking and Data Relay Satellite (TDRS) replenishment progmm in the Treasury, Postal Service and General Government Appropriations Acts, 1997, such 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 ami additions to existing facilities, ami facility planning and design.

Notwithstanding the limitation on the availability of finds 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 30,1999.

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 tmvel expenses of the National Aeronautics and Space Administration shall remain available until September SO, 1997 and may be wed to enter into contracts for training, investigations; cost associated with personnel relocation, and for other services, to be provided during the next fiscal year.

Multi-Year Budget

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1997 ESTIMATES

The FY 1997 multi-year budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685).

The outyear numbers should not be considered final policy numbers. They are going to be refined further by the Administation as it reviews possible savings (in the form of spending reductions or new fees) in all agencies. Once identified, these savings will contribute to adjustments to the outyear numbers for NASA.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
FY **1997 BUDGET ESTIMATES**
IN MILLIONS OF REAL YEAR DOLLARS

FY **1997 PRESIDENT'S BUDGET**

	1995 PAST YEAR	1996 CURRENT YEAR	1997 BUDGET YEAR	1998	1999	2000	2001
HUMAN SPACE FLIGHT	5,515	5,457	5,363	5,081	4,789	4,495	4,918
SPACE STATION	1,890	1,864	1,802				
US/RUSSIAN COOPERATIVE PROGRAM	150	129	138				
SPACE SHUTTLE	3,155	3,149	3,151				
PAYLOAD AND UTILIZATION OPERATIONS	320	315	272				
SCIENCE, AERONAUTICS AND TECHNOLOGY	5,917	5,846	5,862	5,642	5,415	5,184	5,602
SPACE SCIENCE	2,033	2,033	1,857				
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	467	489	499				
MISSION TO PLANET EARTH	1,344	1,289	1,402				
AERONAUTICAL RESEARCH AND TECHNOLOGY	846	846	858				
NATIONAL AERONAUTICAL FACILITIES	35						
SPACE ACCESS AND TECHNOLOGY	605	641	725				
MISSION COMMUNICATION SERVICES	481	441	421				
ACADEMIC PROGRAMS	106	107	101				
MISSION SUPPORT	2,548	2,502	2,562	2,357	2,145	1,930	2,201
SAFETY, RELIABILITY AND QUALITY ASSURANCE	39	38	37				
SPACE COMMUNICATION SERVICES	225	269	291				
RESEARCH AND PROGRAM MANAGEMENT	2,150	2,053	2,079				
CONSTRUCTION OF FACILITIES	135	142	155				
INSPECTOR GENERAL	16	16	17	16	14	13	15
TOTAL BUDGET AUTHORITY	13,996	13,821	13,804	13,096	12,363	11,622	12,736

FY 1996 Changes

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CHANGES FROM FY 1996 BUDGET ESTIMATE TO FY 1996 CURRENT ESTIMATE
(Dollars in Millions)

HUMAN SPACE FLIGHT

The funding level for the Human Space Flight appropriation of **$5,456.6** milllion reflects a reduction of **$53.0** million. The impact of this reduction, and other proposed funding reallocations, are included below.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 Δ	FY 1996 CURRENT ESTIMATE
Space station	1,889.6	1,833.6	**30.0**	**1863.6**
Development	**1,729.2**	1,598.0	**83.4**	1,68**1.4**
Construction of facilities	**20.2**	**14.8**		**14.8**
Utilization support	**31.3**	**67.9**	**-20.5**	**47.4**
Operations	**108.9**	**152.9**	**-32.9**	**120.0**

CHANGE FROM FY 1996 BUDGET ESTIMATE

This net increase of **$30.0** million reflects the management decision to increase the level of funding available for potential changes and contingencies to mitigate the risk of delay during this critical period of activity. The Space Station program contractors are continuing to build up manufacturing capability for production of flight hardware, and **all** critical path items are on schedule to support the first element launch of December **1997.** Funding for Development is increased **$83.4** million, which reflects the transfer of responsibility for development of the Crew Health Care System to the Life and Microgravity Sciences and Applications (LMSA) program and the reallocation of $20.5 million from Space Station Utilization Support, the reallocation of **$32.9** million from Space Station Operations, and the reallocation of $30.0 million from the Space Shuttle program. These actions do not affect program milestones and are accommodated within the **$2.1** billion annual funding limitation in FY **1996** as well as the total program cap of **$17.4** billion.

The reduction in Space Station Utilization Support of **$20.5** million is accommodated by the transfer of utilization support activities and hardware. The transfer of this activity can be accommodated **within** available funding in the LMSA program since the Life Sciences program already has responsibility for other laboratory support equipment and performs user management and integration functions. The reduction in funding for Space Station Operations of **$32.9** million is accommodated through rephasing of planned requirements.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 △	FY 1996 CURRENT ESTIMATE
U.S./Russian cooperation	150.1	129.2		129.2

Although there is no change to the budget request, funding is being reallocated to accommodate support for two additional flights to Mir in 1998.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 △	FY 1996 CURRENT ESTIMATE
Space shuttle	3,155.1	3,231.8	-83.0	3,148.8
Shuttle operations	2,444.3	2,394.8	90.6	2,485.4
Orbiter & integration	528.2	504.9	16.1	521.0
Propulsion	1,007.0	993.2	68.3	1,061.5
Mission and launch operations	909.1	896.7	6.2	902.9
Safety and performance upgrades	710.8	837.0	-173.6	663.4
Orbiter improvements	194.8	227.9	30.8	258.7
Propulsion upgrades..	399.2	458.9	-162.1	296.8
Flight operations & launch site equipment..	104.5	132.8	-42.3	90.5
Construction of facilities	12.3	17.4		17.4

CHANGE FROM FY 1996 BUDGET ESTIMATE

This reduction is consistent with Congressional direction and reflects the savings accrued of $53.0 million from the closure of the Yellow Creek Facility at Iuka, Mississippi and the reallocation of $30 million to Space Station development. We are moving ahead on planning for the implementation of the Consolidated Shuttle Operations Contract. The Space Shuttle program continues to undergo significant restructuring in preparation for this transition. Requirements are being reduced, efficiencies are being sought, hardware designs have been frozen, and civil servants are being transitioned out of Shuttle operations management. The consolidated contract will be implemented in stages, with the first phase beginning in October 1996. Our current schedule anticipates award of a non-competitive contract to the United Space Alliance: however, we have made it clear to the U.S. Alliance that several criteria must be met before any contract will be awarded. As always, the safe operation of the Space Shuttle is the highest priority in NASA. We anticipate that this consolidated contract will result in program efficiencies; however, we do not anticipate these efficiencies resulting in significant program savings before FY 1998.

Over the past year, the Space Shuttle program has focused on resolving nearly $300 million of program requirements which were unfunded in the FY 1996 NASA budget request. Through a detailed review of program requirements and the application of program reserves to the areas of highest risk, all unresolved funding for requirements have been eliminated with no reduction in safety of flight or the flight manifest.

Funding for Space Shuttle Operations totals $2,485.4 million, an increase of $90.6 million over the request. In spite of this increase, Shuttle Operations costs continue to decline, with actual spending rates being reduced by $100 million below the FY 1995 rate.

Funding for Orbiter and Integration is increased $16.1 million: funding for Propulsion is increased $68.3 million: and, funding for Mission Operations is increased $6.2 million. These increases reflect the rebalancing of program requirements following a detailed review of program requirements as well as to prepare for the transition to a consolidated single contractor for Shuttle Operations. Although it is anticipated that the transition to a single prime contractor will result in further program savings in subsequent years, funding must be reallocated to accommodate the expected contract transition period of 18-24 months. This transition time is required to allow the contractor to assemble and train a complete team, including the identification and hiring of selected civil servants to remain on the contractor team.

Funding for Safety and Performance Upgrades is reduced a net of $173.6 million. This reduction reflects the reduction of $53.0 million resulting from the termination of the Yellow Creek facility as directed by Congress, the reallocation of $90.6 million to Space Shuttle Operations, and $30.0 million to Space Station development. Within Safety and Performance Upgrades, funding for Orbiter Improvements is increased $30.8 million: funding for Propulsion Upgrades is decreased $162.1 million: and, funding for Flight Operations and Launch Site Equipment Upgrades is decreased $42.3 million.

The increase in funding of $30.8 million for Orbiter Improvements is required due to the program decision to conduct the Orbiter Maintenance Down Period (OMDP) for OV-105 at the Palmdale, CA facility. During this OMDP, the orbiter will undergo planned refurbishment and will be modified with hardware which will allow docking with the International Space Station. The location of future OMDPs will be determined by U.S. Alliance.

The reduction of $162.1 million in Propulsion Upgrades reflects the application of savings resulting from prior year actions, the reallocation of program reserves to Space Shuttle Operations, and the termination of the Yellow Creek facility. In February 1996, NASA will transferred all rights to the approximately 1,200 acres near Iuka, Mississippi known, as the Yellow Creek Facility resulting in a savings of $53.0 million. To facilitate this conveyance, Congress directed that $10 million of previously appropriated funds shall be transferred to the State of Mississippi to be used in the transition of the facility. Prior year actions which result in reductions to the FY 1996 budget include the termination of the Advanced Solid Rocket Motor program (-$34.0 million), termination of the Lightweight Solid Rocket Booster program (-$10.3 million), elimination of the nozzle buildup activity at Iuka (-$5.6 million) and rephasing of the Super Lightweight Tank program consistent with contractual requirements (-$13.0 million). In addition, $46.2 million has been made available for reallocation due to reduced and reestimated program requirements, the

decision to freeze propulsion system hardware designs, achievement of operational efficiencies. and reserves available due to the termination of the above programs. Of this amount, $30.0 million has been transferred to the International Space Station as noted above. These changes are consistent with the Shuttle Functional Workforce Review, the Zero Base review, and other Shuttle program restructuring efforts. and in no way compromise the program's highest priority of flying safely.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 △	FY 1996 CURRENT ESTIMATE
Payload and utilization operations	320.1	315.0		315.0
Spacelab	90.9	97.0	-10.3	86.7
Tethered re~ght	7.4	3.8		3.8
Payload operations	44.0	30.3	10.3	40.6
Advanced projects	12.2	12.2		12.2
Engineering and technical base	165.6	171.7		171.7

CHANGE FROM FY 1996 BUDGET ESTIMATE

Within the Payload and Utilization Operations program, funding remains unchanged at $315.0 million: however. $10.3 million has been reallocated from the Spacelab program to Payload Operations. This adjustment results from the implementation of recommendations from the Spacelab reengineering process and the Functional Workforce Review completed last year. Savings garnered through the improved Spacelab processes will be applied to meet current-year requirements in Payload Operations. We have also included funds in the Engineering and Technical Base budget to build on research and development efforts at the Marshall Space Flight Center in advanced propulsion systems. As the NASA Center of Excellence in propulsion systems. Marshall will undertake an Advanced Space Transportation technology program. $15.0 million is identifled to begin technology development activities to enable the dramatic reductions in the cost of boosting payloads to low-Earth orbit. This effort will focus on avionics hardware, engine component hardware, test support and propellants for component testing. This initiative is being closely coordinated with the Reusable Launch Vehicle program to ensure that the program planning is completely synergistic.

SCIENCE, AERONAUTICS AND TECHNOLOGY

The funding level for the Science, Aeronautics and Technology appropriation of $5,845.9 million reflects a reduction of $128 million and a general reduction of $33.0 million as directed in House Report 104-384. The distribution of this reduction is: Space Science (-$7.1 million); Mission to Planet Earth (-$10.0 million); Aeronautical Research and Technology (-$10.0 million); and Space Access and Technology (-$5.9 million). The impact of these reductions, and other proposed funding reallocations, are included below.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 Δ	FY 1996 CURRENT ESTIMATE
Space science	2,007.6	1,958.9	48.7	2,007.6
Physics and astronomy	1,187.4	1,131.1	48.7	1,179.8
Advanced x-ray astrophysics facility	224.3	237.6		237.6
Global geospace science	40.0	5.4	-5.4	
Relativity mission development	50.0		51.5	51.5
Payload and instrument development	57.9	33.1	-3.8	29.3
Explorer development..	120.4	129.2	3.0	132.2
Mission operations and data analysis	427.4	428.6	9.2	437.8
Research and analysis	78.3	90.4	12.9	103.3
Suborbital program..	67.2	106.7	-18.7	88.0
Information systems	26.1	25.9		25.9
Launch services	95.8	74.2		74.2

CHANGE FROM FY 1996 BUDGET ESTIMATE

Total funding for Physics and Astronomy is $1,179.8 million, a net increase of $48.7 million from the budget request. This net increase reflects Congressional direction, including funding of $51.5 million for the Relativity Mission (Gravity Probe-B), initiation of the Solar Probes program (+$15.0 million for TIMED and $5.0 million for the Magnetospheric Imager) and additional funding for Explorer Development (+$3.0 million). This increase is offset by reductions to SOFIA development (-$13.7 million) and to SIRTF Advanced Technology Development (ATD) (-$5.0 million), in addition to a reduction of $7.1 million as part of the general reduction to the Science, Aeronautics and Technology appropriation directed by Congress. This general reduction is accommodated by reducing funding for SOFIA development by $5.0 million and funding for initiation of the Magnetospheric Imager mission by $2.1 million. This Operating Plan absorbs the reduction directed to SIRTF. However, the plan also seeks Congressional concurrence with the Agency's proposal to reallocate to SIRTF ATD $5.0 million from other Research and Analysis funds previously intended for SIRTF work, for a revised total of $15.0 million. SIRTF, the last of the Great Observatories, has been the highest priority in the

Astrophysics Strategic Plan for several years, and is crucial for the development of technologies that will enable the search for Earth-like planets around nearby *stars.* The SIRTF program has been dramatically redesigned over the past several years to reduce its size, complexity and total cost.

Congressional direction on the Solar Probes program included funding of $15.0 million for the TIMED mission and $5.0 million to start design studies for the Magnetospheric Imager. This Operating Plan reflects the increase of $15.0 million for TIMED, supporting an aggressive final definition and preliminary design phase for the mission. The Operating plan reduces the amount for Magnetospheric Imager to $2.9 million, based on the fact that the studies cannot get started until late in FY 1996. The planned level for Magnetospheric Imager will be sufficient to fund all required activities in FY 1996, and to carry these activities well into FY 1997.

The $18.7 million reduction to SOFIA development reflects the delayed start of the development phase due to the Government shutdown. Utilizing remaining FY 1996 funding and planned FY 1997 resources, SOFIA will have sufficient funds to begin development in the fourth quarter of FY 1996, and to continue the program through FY 1997 with no delay.

Other funding reallocations are included within Physics and Astronomy to accommodate program changes. $5.4 million is reallocated from Global Geospace Science (GGS) to Mission Operations and Data analysis. The Polar spacecraft was successfully launched on February 24, 1996. As a result, the GGS program has underrun its current development budget and the funding will be reallocated to Mission Operations and Data Analysis allowing for a few additional months of operations for the two GGS spacecraft (Wind and Polar). $3.8 million is also reallocated from SOHO instrument development in Payload and Instrument Development to SOHO Mission Operations and Data Analysis to support an additional 3-4 months of SOHO spacecraft operations. The funding is available due to the successful launch of SOHO on December 2,1995, and to the overall successful cost performance of the program.

Consistent with Congressional direction, funding for Explorer Development is increased $3.0 million. This funding will be used for completion of the Cooperative Astrophysics and Technology Satellite (CATSAT) payload, which had been considered as a backup to two payloads under development as part of the Student Experiment Development Initiative (STEDI). CATSAT will now become the initial payload for the University Explorers (UNEX) program. Within Explorers, funding for the Far Ultraviolet Spectroscopy Explorer (FUSE) has been increased by $8.7 million in order to complete development. This increase is primarily a result of a decrease in foreign participation. Canada was originally going to contribute both the fine-error-sensors and the baffles for the mission, but due to budget difficulties are now providing only the fine-error sensor. In addition, the Germans are no longer providing a telescope. Both the baffles and the telescope are still required This funding is available from within Explorers due to savings in FY 1995 as a result of the successful launch of XTE and slower than planned start of MidEX/Explorer program.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	A	FY 1996 CURRENT ESTIMATE
Planetary exploration..	820.2	827.8		827.8
Cass	255.0	191.5		191.5
Mars instruments	2.1	1.4		1.4
Mars surveyor program..	59.4	108.5	3.4	111.9
Discovery	129.7	103.8	-1.6	102.2
New Millennium Spacecraft		30.0		30.0
Mission operations and data analysis	117.2	127.8	-1.8	126.0
Research and analysis	122.0	109.1		109.1
Launch services.	134.8	155.7		155.7

CHANGE FROM FY 1996 BUDGET ESTIMATE

Funding for Planetary Exploration is unchanged from the requested level of $827.8 million. Within Planetary Exploration, $3.4 million is reallocated from Mission Operations and Data Analysis to the Mars Surveyor program. The increase in Mars Surveyor is required to fund fast-track procurements and maintain its three-year development schedule for the Mars '98 Orbiter and Lander program, with an offsetting outyear reduction. The reduction in Mission Operations and Data Analysis is accommodated by lower than planned funding requirements for Galileo mission operations. Within Discovery, $15.6 million of NEAR development funding is reallocated. $1.6 million is transferred to Mission Operations and Data Analysis for NEAR operations and $14.0 million is reallocated to Lunar Prospector Development. The NEAR funding reallocation can be accommodated due to the excellent performance of the Applied Physics Laboratory, and a successful launch on February 17, 1996. The funding for Lunar Prospector is necessary due to change in the procurement plan for the Lockheed launch vehicle and other fast-track procurements for the program. This reallocation does not increase the total development cost, but represents a zero-sum rephasing with an out-year reduction.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	A	CURRENT ESTIMATE
Life and microgravity sciences and applications	**467.4**	**504.0**	**-15.5**	**488.5**
Life sciences	140.5	134.4	2.0	136.4
Research and analysis	50.7	50.4	4.8	55.2
Flight experiments	89.8	84.0	-2.8	81.2
Microgravity research	127.5	139.9	-6.9	133.0
Research and analysis	30.4	30.2		30.2
Flight experiments	97.1	109.7	-6.9	102.8
Aerospace medicine	6.6	7.0	1.0	8.0
Shuttle/spacelab payload mission management and integration	102.3	85.4	-7.8	77.6
Space station payload facilities	90.5	137.3	-3.8	133.5

CHANGE FR FY 1996 BUDGET ESTIMATE

Funding for Life and Microgravity Sciences is $488.5 million, a net reduction of $15.5 million. This net reduction reflects a general reduction of $20.0 million directed by Congress, offset by an increase of $4.5 million for the Space Radiation program. The general reduction directed by Congress is accommodated by reductions in several program areas. These include: Life Sciences/Flight Programs (-$6.2 million); Microgravity Sciences/Flight Programs (-$6.6 million); and Mission Management (-$7.2 million). Funding changes within the Life and Microgravity Program are also included and outlined below.

Funding for Life Sciences is increased $2.0 million from the requested level, to $136.4 million. This net increase reflects an increase of $4.8 million in Research and Analysis, offset by a reduction of $2.8 million in Flight Programs.

Within Research and Analysis, funding is increased $4.8 million. This increase reflects the addition of $4.5 million to the Space Radiation program directed by Congress, as well as an additional $0.3 million to continue cool suit technology evaluations. The additional funding for the Space Radiation program will be used to establish cooperative agreements with proton cancer therapy centers. These will provide for mutually beneficial science and support, including the sponsorship of peer-reviewed research in radiation biology, the establishment and enhancement of proton radiation facilities, NASA-supported investigators' use of proton

radiation facilities and centers, and the development of research databases and information. This additional funding will make a significant contribution in NASA's efforts to leverage and support the facilities and resources available in the extramural biomedical science community.

The net reduction of $2.8 million for Flight Programs reflects the reduction of $6.2 million as part of the general reduction directed by Congress, and the reallocation of $0.4 million to meet increased requirements in the Aerospace Medicine program, offset by an increase of $1.0 million to support additional flights in FY 1996 of the Space Tissue Loss Facility on the Space Shuttle, and an increase of $2.8 million in Space Station Utilization reallocated from Space Station Payload Facilities. The general reduction is accommodated by deferring investments in small payload science and support where targeted investigations have not been manifested for flight. The reallocation of funding to Life Sciences/Space Station Utilization will provide for more orderly and accelerated station planning, and provide initial funding for ground facilities to support Life Sciences station payloads.

Funding for Microgravity Sciences is reduced $7.9 million. Funding for Research and Analysis is unchanged from the requested level of $30.2 million. Funding for Flight Programs is reduced $7.9 million. This reduction reflects $6.6 million of the general reduction directed by Congress, the reallocation of $1.0 million to Life Sciences for the Space Tissue Loss facility, and $0.3 million allocated to Aerospace Medicine. This is offset by a $1.6 million increase in funding for Space Station Utilization and a $0.6 million reduction for US.-Russian Cooperative program. The $1.6 million increase in funding for Space Station Utilization includes a $1.0 million reallocation from Space Station Payload Facilities. The remaining $0.6 million increase in Space Station Utilization is funded by a reallocation of funding for the US.-Russian Cooperative program. These changes are accommodated by reducing program reserves available to meet unforeseen technical and schedule changes and will provide for experiment unique hardware activities in preparation for the flights of these facilities.

Funding for STS/Spacelab Mission Management and Integration is reduced $7.8 million. $7.2 million of this total reduction reflects the general reduction directed by Congress. Of the remaining reduction, $0.3 million is reallocated to Life Sciences to accommodate the increased requirements for the Cool Suit technology evaluation activities and $0.3 million is reallocated to the Aerospace Medicine program. This total reduction is accommodated through savings realized in the mission management activities that support the Neurolab mission, as well as reductions to the level of program reserves available for program changes.

Funding for the Aerospace Medicine program is increased $1.0 million. This increase is required to meet increasing medical operations workforce requirements for the Phase One Space Station program with Russia.

Space Station Payload Facilities funding has been reduced $3.8 million, and reallocated to the Life Sciences and Microgravity Space Station Utilization programs. This reduction has been accommodated through deferral of planned activities and implementation of cost savings measures, with no impact to the facilities' development schedules. Responsibility for certain Space Station Utilization support activities and support equipment development tasks has been absorbed within the EXPRESS racks/lab support equipment program beginning in FY 1996. The most significant activity transferred from the Space Station program is the crew health care subsystem. By assuming responsibility for this subsystem, commonality between this and other space station facilities under development will be examined, resulting in efficiencies and cost savings.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	—	FY 1996 CURRENT ESTIMATE
Mission to planet earth	**1,310.1**	**1,341.1**	**-91.0**	**1,250.1**
Earth observing system	574.1	591.1	-55.8	535.3
Earth observing system data information System	220.6	289.8	-48.6	241.2
Earth probes	81.6	36.9	4.5	41.4
Payload and instrument development	19.5	4.9	-0.3	4.6
Launch services	48.7	88.0	5.9	93.9
Construction of facilities	17.0	17.0		17.0
Applied research and data analysis	341.3	308.4	3.3	311.7
GLOBE	5.0	5.0		5.0
ACTS	2.3			

CHANGE FROM FY 1996 BUDGET ESTIMATE

This net reduction reflects reductions directed by Congress to the Mission to Planet Earth Program (-$75.0 million) and the CIESIN (-$6.0 million), and an additional reduction of $10.0 million, as part of the general reduction to the Science, Aeronautics and Technology appropriation. The Committees directed NASA in H. Rept. 104-384 to reallocate $5.0 million within available funding to be used toward full development of a Windsat mission. We are in the process of assessing how the Windsat mission would fit in the current complement of instruments and measurements of the MTPE program to meet the objectives specified in the MTPE science plan. We will undertake an initial requirements planning study for the Windsat mission and keep the Congress completely informed of our planning once this analysis is complete.

Total funding for the Earth Observing System (EOS) and EOS Data Information System (EOSDIS) program is reduced $104.4 million. This reduction reflects the results of a comprehensive review of the EOS to reshape mission planning to accomplish a number of interrrelated objectives: substantially reduce EOS life-cycle costs while preserving the basic measurement set; provide now for technology infusion so that it will be available for the second and third EOS series; provide new science opportunities through small satellites; and, adjust program management to an evolutionary approach

Funding for the EOS is reduced a net of $55.8 million. Although the EOS reshaping exercise recognizes that the first series already employs or advances the state-of-the-art in spacecraft and instruments, approximately $75 million of savings were achieved that enable some improvements in the first series, and were reallocated to other parts of the program. These savings were achieved primarily in the AM (-$32.2 million) and PM (-$25.5 million) series of spacecraft, the Chemistry mission (-$0.4 million),

and the Algorithms activity (-$9.7 million). Funding for the Special Spacecraft is increased a net of $2.0 million. This reflects, increased funding of $14.4 million for the ACRIM and Laser-ALT instruments ($6.5 million) to support acceleration of these instruments one year and funding to support participation with the French Space Agency, CNES. in flying a follow-on to the TOPEX/Poseidon mission (TPFO) as the first altimetry radar mission ($7.9 million). These increases are offset by a reduction of $12.4 million in program flexibility and deferring some planned activities in the EOS Color project. $10.0 million has been separately identified within the EOS program to support the New Millennium Program. This program, which involves close cooperation between the Office of Mission to Planet Earth, the Office of Space Science and the Office of Space Access and Technology, will support development of new technology to meet the scientific needs of the next few decades and reduce future EOS costs through focused technology demonstrations for Earth orbiting missions.

Funding for EOSDIS is reduced $48.6 million. Funding for the EOSDIS Backbone Network (EBNET).which transports data to and from the operations control centers and the science data to the Distributed Active Archive Centers (DAACs) is reduced $11.0 million, reflecting network efficiencies. Reductions have also been taken in planned levels of program reserves. Program flexibility is reduced $37.6 million.

Funding for Earth Probes is increased a net of $4.5 million. Funding for the Scatterometer is increased $3.8 million to support program requirements resulting from the ADEOS launch delay. Funding to accommodate this increase has been reallocated from the Scatterometer Mission Operations and Data Analysis budget. $1.0 million is identified to support initiation of the Earth System Science Pathfinder project. This science-driven program is intended to identify and develop small satellite missions to accomplish scientific objectives in response to national and international research priorities that are not being addressed by current programs. This increase is accommodated through reallocation of the savings realized from the reshaping exercise. Funding for TRMM is reduced $0.3 million by reestimating institutional support requirements at Headquarters.

Funding for Payload and Instrument Development is reduced $0.3 million. This reduction reflects a reestimate of institutional support requirements at Headquarters.

Funding for Applied Research and Data Analysis is increased a net of $3.3 million. Funding for Research and Analysis is increased $17.5 million, reflecting the need to bring the science program into balance with the increasing amount of data being produced by the flight program. The redistribution is consistent with the comments and recommendations of external review groups, such as the Board on Sustainable Development. $3.3 million has been reserved for initiation of the transfer of aircraft to Dryden Flight Research Center. $3.8 million is reallocated to Earth Probes for the Scatterometer launch delay and other mission operations is reduced $7.7 million. Consistent with Congressional direction, funding for the Consortium for International Earth Science Information Networks (CIESIN) is deleted (-$6.0 million). At this time, in order to preserve the socioeconomic data capability, the available balance from prior year funds on the NASA contract with CIESIN is expected to be adequate to operate the SEDAC through FY 1996.

Funding for Launch Services is increased $5.9 million. This increase reflects the addition of $6.8 million for launch services to support the New Millennium program, offset by a reduction of $0.9 million for other program support requirements.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 Δ	FY 1996 CURRENT ESTIMATE
Space access and technology	643.9	705.6	-26.7	678.9
Advanced space transportation	162.1	193.0	-4.5	188.5
Spacecraft and remote sensing	174.9	177.5	-3.4	174.1
Advanced smallsat technology	61.9	33.9	5.2	39.1
Space processing	33.3	18.1	35.9	54.0
Flight programs	3.5	76.0	-67.2	8.8
Commercial technology programs	33.8	40.4	-13.0	27.4
Technology transfer agents	12.0		17.1	17.1
Advanced concepts	[3.0]		6.6	6.6
Launch services mission support	38.5	37.6		37.6
Small business and innovative research program	123.9	129.1	-3.4	125.7

CHANGE FROM FY 1996 BUDGET ESTIMATE

This reduction is consistent with Congressional direction. The Space Access and Technology program has restructured its budget to better reflect the management of its programs, and this Operating Plan reflects the new budget structure.

The primary purposes of the realignment are to ensure that closely related activities are managed by a single program manager, and that this manager is accountable for all the activities in each budget line. As a result, several programs were transferred, in their entirety, between budget lines. Space Station Utilization ($37.1 million) moved from Flight Programs to Space Processing, reflecting the fact that most of the Space Station Utilization activity in Space Access and Technology involves materials processing and biotechnology, which are funded in Space Processing. Flight Experiments (IN-STEP) ($30.1 million) moved from Flight Programs to Spacecraft and Remote Sensing, to tie the flight experiments more closely to spacecraft technology developments. Finally, On-Board Propulsion ($4.5 million) moved from Advanced Space Transportation to Spacecraft and Remote Sensing, linking the advanced spacecraft propulsion systems being developed in this effort to the future spacecraft designs and technologies being developed in the Spacecraft and Remote Sensing program. In addition to the transfers, two new budget elements were created: Advanced Concepts ($6.6 million) and Technology Transfer Agents ($17.1 million). Both of these elements contain funding for programs which were previously budgeted in other elements. The new budget lines allow improved management focus on these programs.

Funding for Spacecraft and Remote Sensing is $174.1 million, a net reduction of $3.4 million. This change reflects a reduction of $28.3 million consistent with Congressional direction, and a reduction of $5.2 million to cover increases in the cost of the Lewis spacecraft in the Advanced Smallsat Technology budget element. These reductions are offset by an increase of $30.1 million due

to the budget restructure activity. The reduction of $28.3 million is accommodated by a reduction in funding for the Partnership for a Next Generation Vehicle (PNGV) of $7.0 million and a reduction of $21.3 million to the remainder of the Spacecraft and Remote Sensing program. Both of these reductions reflect Congressional direction. The reduction to the PNGV will terminate activities planned for FY 1996. The reduction in funding for the Spacecraft and Remote Sensing program is accommodated by deleting funding for new flight experiments planned for FY 1996. Funding for activities currently underway will be maintained.

As a result of Congressional action, the Technology Transfer Agents element was increased by a net total of $5.0 million. The Rural States Technology Transfer Center (+$4.5 million) and Commercial Space Activities ($3.0 million) have been added. As part of the general reduction of $33 million to the Science, Aeronautics and Technology appropriation, funding for the National Technology Transfer Center (NTTC) has been reduced $2.5 million. Prior year funds will be applied to meet FY 1996 requirements for NTTC.

SBIR funding has been reduced $3.4 million due to reductions in total NASA Research and Development funding, on which the SBIR funding level is determined.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	A	FY 1996 CURRENT ESTIMATE
Aeronautical research and technology	870.0	917.3	-40.0	877.3
Research and technology base	354.3	354.7	-4.4	350.3
Focused technology programs	493.7	557.2	-30.2	527.0
High performance computing & communications	76.1	75.2	-11.6	63.6
Materials & structure systems technology	24.3			
Numerical aerodynamic simulation	46.2	48.1		48.1
High-speed research	221.3	245.5		245.5
Advanced subsonic technology	125.8	188.4	-18.6	169.8
Construction of facilities	22.0	5.4	-5.4	

HA FROM FY 1996 GET IE

This reduction is consistent with Congressional direction, and reflects a specific reduction of $30.0 million to the Aeronautics program, as well as a reduction of $10.0 million as part of the general reduction to the Science, Aeronautics and Technology appropriation.

Funding for the Research and Technology Base is reduced $4.4 million as part of the general reduction directed by Congress. This reduction will be accommodated through an acceleration of planned efficiency reductions at the Aeronautics Research Centers from FY 1997 into FY 1996. The planned efficiency reductions include facility closures, contract consolidations, support service contractor eliminations, and information resources management reductions.

Funding for the High Performance Computing and Communications (HPCC) program is reduced $11.6 million. This reduction will be accommodated by delaying planned activities across this program. Planned award of Earth and Space Sciences computational research and testbed activities will be delayed. Several current Information Infrastructure Technology and Applications (IITA) awards will be reduced and future solicitations terminated. Funding to support NASA's joint venture in Digital Library projects with the National Science Foundation and the Department of Defense/ARPA will also be reduced. Funding to initiate the Remote Exploration and Experimentation program within HPCC will commence at the level of $0.6 million.

Funding for the Advanced Subsonic Technology (AST) program is reduced $18.6 million. Within AST, the Advanced Air Transportation Technology (AATT) program will be initiated at a reduced level of $6.4 million which is $13.6 million less than the requested level, and funding for the Affordable Design and Manufacturing (ADAM) program is reduced $5.0 million. The reduction to the AATT program will be accommodated by reducing the number of industry and university concepts involved in the AATT program, and by deferring four of the six technology investigations planned for FY 1996 until FY 1997. In addition, funding for industry participation in the development of modeling capabilities will be reduced. The ADAM program was proposed for initiation in FY 1996. This program is now eliminated.

$5.4 million of Construction of Facilities funding for the Modernization of the Unitary Plan Wind Tunnel Complex has been deleted and resources required to complete this project are currently under review. If additional funds are needed to complete this project, FY 1994 funds will be redirected in accordance with the provision in the Conference Report accompanying H.R. 2099.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	A	FY 1996 CURRENT ESTIMATE
Mission communication services..	**481.2**	**461.3**	**-20.0**	**441.3**
Ground network	273.4	268.8	-11.1	257.7
Mission control and data systems	175.8	162.2	-8.9	153.3
Space network customer services	32.0	30.3		30.3

CHANGE FROM FY 1996 BUDGET ESTIMATE

This reduction reflects a general reduction of $20.0 million to the Mission Communications Services program as directed by Congress. The reduction will be accommodated by implementing additional economies in support service contractor staffing levels,

and achieving operational efficiencies in areas such as engineering activities, mission and strategic planning, quality assurance, logistics, documentation and configuration management. Funding for the Ground Network program is reduced by $11.1 million. Some specific reductions in this program are (1) deferring the 34-meter arraying capability at Goldstone until FY 1998, (2) deleting the 200 watt S-band transmitters for the 26-meter subnet, and (3) deleting the ATM upgrade for network communications. Funding for the Mission Control and Data Systems is reduced by $8.9 million. Specific reductions in this program will be accommodated by (1) achieving operational efficiencies as stated above and (2) reducing the Maintenance and Operations staffing through normal attrition, and as reengineering efforts take effect, which includes extensive reuse of software.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 Δ	FY 1996 CURRENT ESTIMATE
Academic programs	**102.2**	**118.7**	**-16.5**	**102.2**

CHANGE FROM FY 1996 BUDGET ESTIMATE

This reduction is consistent with Congressional direction. Within Academic Programs, funding for Education Programs is reduced $5.1 million and funding for the Minority University Research Program is reduced $11.4 million.

The reduction to the Education Programs budget maintains funding for this program at the FY 1995 level. This reduction will be accommodated by maintaining all activities at the current level, rather than increasing the participation of students, teachers and faculty members as was planned. We are currently evaluating whether resources would permit funding for other projects aimed at significantly enhancing science, educational, and outreach services for an underserved region of the country, as suggested in House Report 104-384.

The reduction to the Minority University Research Program will be accommodated by maintaining funding levels at the FY 1995 level. This will reduce the number of planned Announcements of Opportunity from six to two, as well as limiting the funding for unsolicited awards to a maximum of two years. In addition, funding for Undergraduate and Graduate Student Research Programs has been reduced and redirected to students at Historically Black Colleges and Universities and Other Minority Universities.

MISSION SUPPORT

The funding level for the Mission Support appropriation of $2,502.2 reflects a reduction of $224.0 million. The impact of this reduction is included below.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	Δ	FY 1996 CURRENT ESTIMATE
Safety, reliability & quality assurance	**38.7**	**37.6**		**37.6**

There is no change in total funding for Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) activities

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	Δ	FY 1996 CURRENT ESTIMATE
Space communications services	**226.0**	**319.4**	**-50.0**	**269.4**
Space network	110.1	206.7	-50.0	156.7
Telecommunications	114.9	112.7		112.7

CHANGE FROM FY 1996 BUDGET ESTIMATE

This reduction reflects a $50.0 million general reduction from Space Communications Services, as directed by Congress. TDRS Replenishment is reduced $45.4 million. Of this amount of $40.4 million is available as a result of the latest contract negotiation of the TDRS Replenishment Program and $5.0 million is available from the FY 1995 TDRS Replacement (F-7) program which was successfully launched. The remaining reduction of $4.6 million will be accommodated by reducing flexibility to meet unexpected changes in the implementation, maintenance, and operation of the communications systems and facilities necessary to ensure and sustain high quality performance of NASA's flight systems.

	FY 1994 ACTUAL	FY 1996 BUDGET ESTIMATE	A	CURRENT ESTIMATE
Construction of facilities	135.0	166.4	-24.0	142.4

This reduction is consistent with Congressional direction. The impact of this reduction is accommodated by Congressional direction to identify FY 1996 CofF requirements to which $24 million available from the FY 1994 Construction of Facilities appropriation *can* be applied. The $24 million results from favorable bids experienced in the marketplace, construction efficiencies realized from innovative designs, scope reductions due to efforts to downsize the Agency's physical plant as well as Zero Base Review determinations, and the design of fewer projects for future budgets due to constrained Agency resources. This funding is available from "Replacement of Central Plant Steam and Electrical Generation Equipment" ($0.2 million) at the Goddard Space Flight Center: "Restore C-5 Substation, Launch Complex 39 Area" ($1.5 million), "Refurbish Launch Complex 39 Cooling System" ($1.3 million). "Restore Class III Landfill ($0.6 million). and "Refurbish VAB/Pad Water Storage Tanks" ($0.8 million) at the Kennedy Space Center: "Construction of the EOSDIS Distributed Active Archive Center" ($0.2 million) at the Langley Research Center: 'Modifications for Composite Technology Center ($8.0 million) and "Rehabilitation of the Rocket Engine Test Facility" ($4.0 million) at the Lewis Research Center: "Restoration of High Pressure Air Compressor System ($0.8 million) at the Marshall Space Flight Center: and 'Facility Planning and Design" ($6.6 million) at various locations.

Within the planned funding level for Facility Planning and Design in FY 1996, $8 million will be reallocated to begin two activities directed at increasing the rate of return of severely constrained Agency resources while keeping the aging facility infrastructure safe, reliable, and available. The first program reorients maintenance planning throughout NASA from a time-driven and reactive mode to a more proactive program of reliability-centered maintenance. It also aims to utilize system performance feedback to design potential failures out of systems. The second provides the substantial upfront effort required to convert maintenance contracts from cost-reimbursement to performance based, fuzed price contracts. Currently about 90% of NASA contracts for these services are cost-reimbursement contracts. These two activities will be implemented over the next three years. Funding to support the final increments will be included in future FP&D budget requests.

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 Δ	FY 1996 CURRENT ESTIMATE
Research and program management	**2,149.6**	**2,202.8**	**-150.0**	**2,052.8**
Personnel and related cost	1,628.9	1,690.1	-125.0	1,565.1
Travel	44.9	45.5		45.5
Research operations suppo	475.8	467.2	-25.0	442.2

CHANGE FROM FY 1996 BUDGET ESTIMATE

This reduction is consistent with Congressional direction. Within Research and Program Management, funding for Salaries and Expenses is reduced $125.0 million and funding for Research Operations Support is reduced $25.0 million.

Within Research and Program Management, the reduction to Salaries and Expenses is accommodated through savings resulting from the buyout of 1,431 employees in FY 1995 and from an agency-wide hiring freeze in FY 1995 and FY 1996. The reduction to funding for Research Operations Support is accommodated by reduced levels of funding for facility maintenance, supplies and materials, reduced support contractor support and a reduced level of administrative equipment purchases

	FY 1995 ACTUAL	FY 1996 BUDGET ESTIMATE	FY 1996 —	FY 1996 CURRENT ESTIMATE
INSPECTOR GENERAL	**15.8**	**17.3**	**-1.3**	**16.0**

This funding reduction is consistent with Congressional direction. In addition, all investigative staff are entitled to a 25% pay premium as mandated by the Law Enforcement Availability Pay Act of 1994. The impact of this requirement is $700,000 per year. This total reduction will be accommodated by accelerating planned personnel reductions from FY 1997 into FY 1996, and through implementing creative changes and improvements in organizational structure and business process. These changes include the downsizing of the Headquarters staff, reduction in administrative support positions, elimination of supervisory and management layers, and the establishment of a new Inspections and Assessments element within existing staff resources. These changes will allow the OIG to monitor, assist, and review the Agency's programs and operations to assure efficiency, effectiveness, integrity and economy.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1997 ESTIMATES
ANALYSIS OF NASA/RUSSIAN CO MIR PROGRAM

	FY 1995	FY 1996	FY 1997
		(Thousands of dollars)	
HUMAN SPACE FLIGHT			
US-Russian cooperative program	150,100	129,200	138,200
(Russian support)	(100.000)	(100,000)	(100,000)
(Mir)	(50.100)	(29.200)	(38.200)
International Space Station (Flight technology demonstrations)	30.000	8.300	3.200
SCIENCE, AERONAUTICS AND TECHNOLOGY			
Russian cooperation*	63,000	59,200	37,800
(Life sciences)	(16,400)	(19,800)	(13,200)
(Microgravity)	(11.300)	(8,700)	(6,800)
(Spacelab mission management)	(27.700)	(24,400)	(16,800)
(Aerospace medicine)	--	--	(500)
(Space access and technology)	(7,600)	(6,300)	(500)
To	243.100	196.700	179.200

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

The cooperative U.S.-Russian Mir program consists of nine flights of the Space Shuttle to the Mir Space Station (two new flights being added in 1998 in this budget request), 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 Me of the Mir station through 1998. The first two flights of this joint program were completed in 1995. All flights will carry pressurized experiments, hardware, logistics and supplies to the Mir utilizing both Spacelab and Spacehab modules. Russia is enhancing the Mir capabilities by adding two experiment/logistics modules to the core Mir station -- Spektr, which was deployed in 1995. and Priroda, which will be launched in 1996, both of which will also c a r U.S. hardware. Other flights will supply logistics and Mir life-extension hardware, and conduct flight technology demonstrations. The budget estimates included above remain subject to final negotiations involving the newly-added eighth and ninth flights.

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1997 ESTIMATES
ALYSIS OF AGENCY SUPPORT FOR INTERN L SPA(STATION

	FY 1995	FY 1996	FY 1997
		(Thousands of dollars)	
HUMAN SPACE FLIGHT			
International space station	1,889,600	1,863,600	1.802.000
Russian cooperation	50.100	29.200	38.200
SCIENCE, AERONAUTICS & TECHNOLOGY			
Life and microgravity sciences and applications			
Russian cooperation	55,400	52,500	37,300
(Life sciences)	(16,400)	(19,800)	(13,200)
(Microgravity)	(11,300)	(8,700)	(6,800)
(Spacelabmission management)	(27,700)	(24,000)	(16,800)
(Aerospace medicine)	(--)	(--)	(500)
International space station facility payloads	90,500	133,500	187,100
International space station utilization	12.300	24,800	43.400
(Life sciences)	(500)	(7,000)	(11.200)
(Microgravity)	(11,800)	(17,800)	(32.200)
Mission to planet Earth international space station attached payload.	--	3,700	9,000
Space access and technology international space station utilization	15.000	36.300	31.600
To	2.112.900	2.143.600	2.148.600

International 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 International Space Station, and the flight support component of the Russian cooperation program of joint flights to the Mir Space Station. Recently, the joint flights to Mir were increased from seven to nine missions in order to provide for extended Mir operations. Both programs are managed by the Office of Space Flight. International 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 International 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 International 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 International Space Station deployment.

National Aeronautics and Space Administration

Full Funding for Fixed Assets

As part of an ongoing effort to improve planning and budgeting for the acquisition of fixed assets and similar procurements, the President's 1997 budget includes an allowance for the additional budget authority required to fully fund certain projects. The incremental budget authority required in 1997 for each of the projects is requested as an appropriation to the regular agency account for that project. The additional amounts of budget authority required for full funding are requested in a Government-wide general provision. This method of requesting the additional budget authority is proposed only for this transition year. In future budgets, all of the budget authority for fully funding similar projects will be requested as an appropriation to the regular agency account.

For this year, NASA is requesting $342 million in upfront funding for the New Millennium Initiative and $558 million for the Tracking and Data Relay Satellite (TDRS) replenishment. Upfront funding will enable better cost controls and savings through improved planning and greater management flexibility and accountability.

The upfront funding for the New Millennium Initiative is the outyear budget needed to provide the life-cycle cost, including spaced development, launch, mission operations and data analysis for five new space missions:

($ in millions)	1997 Request	Upfront Request	Life Cycle Cost
Discovery	32.0	122.5	154.5
Medium Explorer (MIDEX)	25.2	92.0	117.2
Small Explorer (SMEX)	5.1	62.0	67.1
University Explorer (UNEX)	7.1	4.5	11.6
Earth System Science Pathfinder (ESSP)	20.0	61.0	81.0
New Millennium Initiative Total	**89.4**	**342.0**	**431.4**

The upfront funding for TDRS replenishment is the outyear budget for the procurement of the three spacecraft and the associated, launch services. This funding would help maintain the cost advantage of this unique fixed-price contract and could also better enable the eventual commercialization of the space network.

($ in millions)	Prior	1997 Request	Upfront Request	Life Cycle Cost
TDRS Replenishment Spacecraft	**198.5**	**180.0**	**558.0**	**936.5**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1997 BUDGET

Budget Authority in Millions

	FY 1995	FY 1996	FY 1997
Human Space Flight	7,212	7,158	7,069
Space Science	2,676	2,653	2,476
Mission to Planet Earth	1,840	1,779	1,901
Aeronautics	1,454	1,387	1,422
Space Access and Technology	799	829	919
Subtotal	13,981	13,805	13,786
Inspector General	16	16	17
Total, NASA	13,996	13,821	13,804

NASA's Strategic Plan consists of five Enterprises. The budget display immediately above provides an approximation of how the NASA budget request would appear on an enterprise basis. A number of supporting program elements are allocated to generate this display, including civil service personnel and expenses: personnel benefits and supporting activities; research operations support: travel of civil service personnel: facilities construction and maintenance: safety, reliability. and quality assurance: mission communications and space communications: and, academic programs. The figures should be considered preliminary and only as approximations. NASA is developing methodology to generate the budget on a "full-cost" basis. The derivation of cost allocation algorithms is a key development for that process.

National Aeronautics and Space Administration

Major NASA Development Programs
Program Cost Estimates

This special section of the FY 1997 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 1995 and prior fiscal year budget authority are the "actual" amounts. The FY 1996 amounts *are* consistent with the proposed NASA Operating Plan as of February 1996. The amounts for FY 1997 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 costs have been included, but these estimates should be considered preliminary, and they will continue to be refined as the agency moves toward full cost accounting over the next two years.

* *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 2002. 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 approprlation for this program. They do not include the amounts being contributed by industry, or for the use of government facilities and general support used to carry out the research. A more detailed exposition of the program goals. objecttves and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

Hi S	PRIOR	1996	1996	1997	1998	1999	2000	2001	Balance	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	469.1	221.3	245.5	254.3	268.1	188.5	106.1	69.8	73.8	1,886.5
(ESTIMATED C M L SERVICE FTEs)	(1,223)	(643)	(636)	(649)	(652)	(552)	(389)	(369)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	73.0	45.8	45.2	48.9	52.2	45.8	33.3	32.4		

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 2004.

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. or for the use of government facilities and general and administrative support used to carry out the research. A more detailed exposition of the program goals, objecttves and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

Advanced Subsonic Technology	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	106.7	125.8	160.8	187.2	223.1	199.8	142.6	167.9	345.5	1,668.3
(ESTIMATED CIVIL SERVICE FTEs)	(340)	(433)	(465)	(540)	(550)	(507)	(391)	(328)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	21.0	30.8	33.1	40.6	44.1	42.0	33.5	28.8		

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 Anal 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 Anal 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 Shuffle 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 Anal 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 the U.S. element assembly milestone in June 2002 is accomplished. They do not include the amounts being contributed by the international partners, the $400 million contract with the Russian Space Agency, the costs of the non-program unique NASA facilities, Shuffle 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 $7.9 billion. Five flights largely dedicated to partner elements are estimated at $2.2 billion. An additional 6 Shuttle flights will be made for science and technology utilization purposes during the assembly period: at average costs, these utilization flights are estimated at $2.5 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	2001	Balance *	TOTAL
PROGRAM ELEMENTS WITHIN $2.1 BILLION ANNUAL FUNDING CAP		**2,106.0**	**2,112.9**	**2,143.6**	**2,148.6**	**2,121.3**	**2,109.2**	**1,914.6**	**1,596.8**	**1,147.0**	**17,400.0**
HUMAN SPACE FLIGHT	**10,234.1**	**2,010.0**	**1,939.7**	**1,892.8**	**1,840.2**	**1,720.8**	**1,674.7**	**1,460.6**	**1,282.5**	**951.6**	**25,007.0**
SPACE STATION	10,113.1	1,939.2	1,889.6	1,863.6	1,802.0	1,703.5	1,674.7	1,460.6	1,282.5	951.6	24,680.4
DEVELOPMENT	9,190.4	1,918.2	1,749.4	1,696.2	1,513.2	1,096.6	855.6	525.4	257.9	199.7	19,002.6
UTILIZATION SUPPORT	175.21	21.0	31.3	47.4	72.1	56.7	57.2	49.9	46.9	41.8	424.3
OPERATIONS			108.9	120.0	216.7	550.2	761.9	885.3	977.7	710.1	4,330.8
OTHER	922.7										922.7
U.S./RUSSIAN COOP PROG	121.0	70.8	50.1	29.2	38.2	17.3					326.6
SCIENCE, AERONAUTICS & TECHNOLOGY		**96.0**	**173.2**	**250.8**	**306.4**	**400.5**	**434.5**	**454.0**	**314.3**	**195.4**	**2,627.1**
LIFE & MICROGRAVITY SCIENCES		96.0	158.2	210.8	267.8	345.0	379.1	396.9	257.1	161.3	2,272.2
SPACE STATION FACILITIES		37.0	90.5	133.5	187.1	246.6	256.9	237.1	173.2	71.3	1,433.2
LIFE SCIENCES & AEROSPACE MEDICINE		31.5	16.9	26.8	24.9	40.8	56.7	84.8	35.0	45.0	362.4
MICROGRAVITY RESEARCH		16.3	23.1	26.5	39.0	53.6	64.5	75.0	48.9	45.0	391.9
STS/SPACELAB MISSION MANAGEMENT		11.2	27.7	24.0	16.8	4.0	1.0				84.7
SPACE ACCESS AND TECHNOLOGY			15.0	36.3	31.6	51.1	52.8	53.7	53.7	34.1	328.3
MISSION TO PLANET EARTH (SAGE III)				3.7	9.0	4.4	2.6	3.4	3.5		26.6
(ESTIMATED CIVIL SERVICE FTEs)	(3,245)	(1,283)	(1,441)	(1,698)	(1,698)	(1,655)	(1,589)	(1,424)	(1,333)		
CML SERVICE COMPENSATION ESTIMATE ($M) **	164.5	85.9	102.6	120.8	127.8	132.6	131.8	122.0	117.1		

* Balance of estimate is for 9 months of the fiscal year. through June 2002 (U.S. assembly complete)
** Civil Service estimates include only FTEs for the International Space Station within Human Space Flight

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 occurred in 1995, and the initial flight of the fuel pump will be in 1997. 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 night 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 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)

Alternate Turbopump Development	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT	491.7	46.8	69.3	61.3	39.4	16.0	6.0			730.5
IMPLEMENTATION	32.2	35.5	52.3	83.3	62.7	24.1	9.8			299.9
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	623.8	82.3	121.8	144.6	102.1	40.1	16.8			1,030.4
(ESTIMATED CIVIL SERVICE FTEs)	(344)	(66)	(61)	(55)	(29)	(22)	(22)			
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	19.7	4.7	4.3	4.1	2.3	1.8	1.9			

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 7500 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 late 1997. In addition to the design and development costs, the figures shown 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 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)

Super Lightweight Tank	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT COST	50.8	41.2	44.1	31.2	4.2	1.0				172.5
RECURRING COST	9.2	19.5	27.3	31.9	33.1	33.1	8.5		Cont	162.6
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	60.0	60.7	71.4	63.1	37.3	34.1	8.6			335.1
(ESTIMATED CIVIL SERVICE FTEs)	(3)	(70)	(76)	(57)	(12)	(2)	(2)	(2)		
C M L SERVICE COMPENSATION ESTIMATE ($M)	0.2	5.0	5.4	4.3	1.0	0.2	0.2	0.2		

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, or for 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 section.

Advanced X-Ray Astrophysics Facility

(Budget Authority in Millions of Dollars)

Advanced X-Ray Astrophysics Facility	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
ADVANCED TECH DEVELOPMENT	54.2									54.2
DEVELOPMENT	719.5	224.3	237.6	178.6	92.7					1,452.7
MISSION OPS & DATA ANALYSIS	33.6	18.9	40.4	41.3	45.7	64.2	63.9	68.4	147.3	523.7
UPPER STAGE	15.9	17.5	15.3	16.0	5.8					70.5
STS LAUNCH SUPPORT					476.5					476.5
TRACKING & DATA SUPPORT	0.1	0.2	0.5	0.4	0.3	0.2	0.2	0.2	1.6	3.7
CONSTRUCTION OF FACILITIES	17.7									17.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	841.0	260.9	293.8	236.3	621.0	64.4	64.1	68.6	148.9	2,599.0
(ESTIMATED CIVIL SERVICE FTEs)	(709)	(343)	(305)	(256)	(203)	(57)	(27)	(22)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	40.8	24.4	21.7	19.3	16.3	4.7	2.3	1.9		

Relativity Mission/Gravity Robe-B

The development of the Relativity 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. The budgetary estimates below include *funding* for the experiment development activities initiated in 1993. a minimum of 16 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 Shuffle Test of Relativity Experiment program initiated in FY 1988 and subsequently restructured into a ground test program only. The estimates also exclude: the non-program-unique government facilities and general and administrative support used to *cany* 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 section.

(Budget Authority in Millions of Dollars)

Relativity Mission/Gravity Probe-B	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT	169.8	50.0	51.5	59.6	46.6	55.5	35.8	4.1		472.9
MISSION OPS & DATA ANALYSIS								20.8		20.8
LAUNCH SUPPORT				8.0	22.5	18.5	7.7			56.7
TRACKING & DATA SUPPORT										0.0
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	168.8	50.0	61.6	67.6	68.1	74.0	43.6	24.9		550.4
(ESTIMATED CIVIL SERVICE FTEs)	(40)	(22)	(21)	(32)	(60)	(61)	(59)	(49)		
CIVIL SEHVICE COMPENSATION ESTIMATE ($M)	2.3	1.6	1.5	2.4	4.8	5.1	5.1	4.3		

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 launched successfully on a Delta 11 launch vehicle in November 1994. The Polar spacecraft was launched successfully in February 1996, also on a Delta II. The budgetary estimates provide for the experiment and spacecraft development, a 2.5-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, or for 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 section.

(Budget Authority in Millions of Dollars)

Global Geospace Science Missions	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT	412.7	40.0	5.4							458.1
MISSION OPS & DATA ANALYSIS	8.4	8.8	21.1	25.5	15.7					79.5
LAUNCH SUPPORT	112.4	4.2	3.0							119.6
TRACKING & DATA SUPPORT	24.6	1.5	0.9	0.1	0.1					27.2
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	558.1	54.5	S0.4	25.6	16.8					684.4
(ESTIMATED CIVIL SERVICE FTEs)	(628)	(56)	(16)	(8)	(5)	(5)	(5)			
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	36.1	4.0	1.1	0.6	0.4	0.4	0.4			

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 II. The December 1995 launch of the ESA Solar and Heliospheric Observatory (SOHO) was on a U.S.-funded Atlas IIAS. The four Cluster spacecraft are scheduled for launch in May 1996, on an Mane V. Mission operations and data analysis provides for spacecraft operations. 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 work force salary and expenses (S&E), and the use of non-program-unique government facilities and general and administrative support used to *cany* out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specifiicbudget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001 Balance	TOTAL
Collaborative Solar Terrestrial Research Program									
DEVELOPMENT	307.7	23.3							331.0
MISSION OPS & DATA ANALYSIS	17.2	11.7	31.9	28.4	8.5				97.7
LAUNCH SUPPORT	145.4	30.7							176.1
TRACKING & DATA SUPPORT	34.2	4.6	1.2	0.2	0.2				40.4
TOTAL EXCLUDING CIVIL SERVICE COSTS ($4	504.5	70.3	33.1	28.6	8.7				645.2
(ESTIMATED CIVIL SERVICE FTEs)	(351)	(95)	(60)	(32)	(25)	(20)	(20)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	20.2	6.8	4.3	2.4	2.0	1.7	1.7		

The Explorer Program

The Explorer 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, launch services, mission-unique tracking and data acquisition support, mission operations and data analysis. It does not include costs for the use of government facilities and general and administrative support required to implement 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 Space Science section.

(Budget Authority in Millions of Dollars)

The Explorer Program	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
X-Ray Timing Explorer	212.9	40.2	13.9	10.4	5.0	5.6				288.0
Advanced Composition Explorer	34.9	59.1	60.1	44.2	15.2	7.8	7.4	3.6	1.8	234.1
Far Ultraviolet Spectroscopy Explorer			43.4	49.9	38.5	13.2	9.4	9.4		163.8
Medium Explorers		1.0	15.2	25.0	64.7	85.0	74.2	86.6	Continuing	
Small Explorers		47.2	56.3	56.0	53.6	61.5	66.4	66.0	Continuing	
University Explorers				7.1	10.8	13.6	11.0	11.3	Continuing	
Planning & Future Developments	14.2	12.7	7.0	12.4	18.6	27	25.2	25.1	Continuing	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	262.0	160.2	106.0	205.0	206.4	213.7	105.8	202.0	1.8	1,640.6
(ESTIMATED CIVIL SERVICE FTEs)	(1,248)	(289)	(267)	(288)	(248)	(213)	(232)	(248)	(Cont)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	71.8	20.6	19.0	21.7	19.9	17.7	19.9	21.8	Cont	

X-Ray Timing Explorer

Development on the X-Ray Timing Explorer (XTE) began in FY 1990. The spacecraft was an in-house build at the Goddard Space night Center; instruments were developed by the principal investigators. The XTE was launched successfully in December 1995 on a Delta 11 launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT	172.6	21.6								194.2
MISSION OPS & DATA ANALYSIS		1.0	11.0	10.1	5.0	5.6				32.7
LAUNCH SUPPORT	32.2	13.3	1.3							46.8
TRACKING & DATA SUPPORT	8.1	4.3	1.6	0.3						14.3
TOTAL	**212.9**	**40.2**	**13.9**	10.4	**5.0**	**5.6**				**288.0**

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 between August 1997 and December 1997 on a Delta 11 launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT	33.2	44.1	31.5	24.7	7.5					141.0
MISSION OPS & DATA ANALYSIS				1.0	6.9	7.2	7.4	3.6	1.8	27.9
LAUNCH SUPPORT	0.9	11.5	24.0	15.1						51.5
TRACKING & DATA SUPPORT	0.8	3.5	4.6	3.4	0.8	0.6				13.7
TOTAL	**34.9**	**59.1**	**60.1**	**44.2**	**15.2**	7.8	7.4	5.6		**234.1**

Far Ultraviolet Spectroscopic Explorer

Development on the Far Ultraviolet Spectroscopy Explorer (FUSE) began in FY 1996. The FUSE mission has been restructured from a Delta-class explorer in order to reduce costs and accelerate the launch date from CY 2000 to November 1998. FUSE is being *managed* by Johns Hopkins University, with contributions from the University of Colorado, the University of California-Berkeley, Orbital Sciences Corp., Canada and France.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT			39.0	39.6	*26.8*	2.6				108.0
MISSION OPS & DATA ANALYSIS						7.0	9.4	9.4	TBD	*25.8*
LAUNCH SUPPORT			4.4	10.3	11.7	3.6				30.0
TOTAL			43.4	49.9	38.5	13.2	9.4	9.4		163.8

Stratospheric Observatory for Infrared Astronomy

The initial development funding for the Stratospheric Observatory for Infrared Astronomy (SOFIA) was requested in the FY 1996 budget. This new airborne observatory will provide a significant increase in scientific capabilities over the Kuiper Airborne Observatory, which was retired in October, 1995. The Kuiper was a Lockheed C-141A aircraft with a 0.9-meter reflecting telescope, used to conduct scientific investigations at infrared and submillimeter wavelengths. The SOFIA will be accommodated in a Boeing 747 and will feature a 2.5-meter infrared telescope to be provided by the German Space Agency (DARA). The initial operational date for SOFIA will be at the end of 2000.

The budgetary estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the costs of preliminary design studies carried out in previous years. the amounts being contributed by the international participants, or costs for the use of government facilities and general and administrative support used to carry out the research and development activities. They also do not include civil service pay and benefits, because civil service FTE levels have not been established yet for this new program. 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 section.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT			30.0	26.3	63.2	65.8	45.6			230.9
MISSION OPERATIONS							11.6	35.3	Cont	Cont
TOTAL EXCLUDING CIVIL SERVICE COSTS			30.0	26.3	63.2	65.8	67.2	35.3		277.8

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 IV launch vehicle. The spacecraft will arrive at Saturn in 2004 and 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, or for the use of government facilities and general and administrative support required to implement the program. A more detailed descrlption of the program goals, objectives and activities is provided in the speciflc budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
CASSINI										
DEVELOPMENT	854.8	255.0	191.5	106.7	13.7					1.421.7
MISSION OPS & DATA ANALYSIS					48.4	55.8	55.0	56.6	535.2	751.0
LAUNCH SUPPORT	119.4	81.0	89.1	100.3	39.3					429.1
TRACKING & DATA SUPPORT	16.4	3.2	2.0	2.6	5.3	9.0	6.0	8.0		52.5
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	990.6	339.2	282.6	209.6	106.7	64.8	61.0	64.6	535.2	2,654.3
(ESTIMATED CIVIL SERVICE FTEs)	(282)	(107)	(69)	(31)						
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	16.8	7.6	4.9	2.3						

Discovery Missions

Discovery missions are planetary exploration missions 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 three approved Discovery missions, the Mars Pathfinder, the Near Earth Asteroid Rendezvous (NEAR) and the Lunar Prospector. A fourth mission, Stardust, has been selected to initiate Phase B design analysis, and following normal new start review procedures, Phase C/D start is planned at the beginning of FY 1997. Life cycle cost estimates will be made available for Stardust after the mission has proceeded sufficiently into Phase B analysis during FY 1996 to allow firm estimates. 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 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 costs for 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)

Discovery Missions	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
MARS PATHFINDER	79.4	109.4	55.7	13.1	6.0	2.0				265.6
NEAR	91.2	66.0	20.6	8.7	9.7	15.0	8.8	0.2	0.3	220.5
LUNAR PROSPECTOR			36.4	20.6	4.3					61.3
FUTURE MISSIONS			23.8	60.8	127.9	173.3	182.4	194.2	Cont	762.4
TOTAL EXCLUDING CIVIL SERVICE COSTS ($4	170.6	176.4	136.5	103.2	147.0	190.3	101.2	194.4	0.3	1,309.8
(ESTIMATED CIVIL SERVICE FTEs)	(15)	(16)	(16)	(16)	(16)	(37)	(37)	(37)	(Cont.)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	1.0	1.1	1.1	1.2	1.3	3.1	3.2	3.3	Cont.	

Mars Pathfinder

The Mars Fkthflnder 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 a unique cruise, entry, descent, and landing system approach that will be available for future missions to Mars. Launch is scheduled for December 1996 on a Delta 11 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	1995	1996	1997	1998	1999	2000	2001 —e	TOTAL
DEVELOPMENT	60.8	79.7	33.7						174.2
MICROROVER	8.7	8.5	5.8	2.0					25.0
MISSION OPS & DATA ANALYSIS				9.6	5.8	2.0			17.4
LAUNCH SUPPORT	9.9	21.1	16.0	1.3					48.3
TRACKING & DATA SUPPORT		0.1	0.2	0.2	0.2				0.7
TOTAL	79.4	109.4	66.7	13.1	6.0	2.0			265.6

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 was 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. The *NEAR* spacecraft was launched February 17,1996 on a Delta 11 launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT	66.6	50.0	8.3							124.9
MISSION OPS & DATA ANALYSIS			4.9	8.5	9.5	14.8	8.6			46.3
LAUNCH SUPPORT	24.6	15.9	7.2							47.7
TRACKING & DATA SUPPORT		0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	1.6
TOTAL	91.2	66.0	20.6	8.7	9.7	16.0	8.8	0.2	0.3	220.5

Lunar Prospector

Lunar Prospector was selected as the third Discovery mission in FY 1995, and Phase C/D development started in the first quarter of FY 1996. The mission is designed to search for resources on the Moon, with special emphasis on the search for water in the shaded polar regions. Ames Research Center is managing the mission. and Lockheed Martin will provide the spacecraft. instruments, launch and operations. Launch will be on a Lockheed Launch Vehicle-II (LLV-II) and is planned for October 1997. Tracking and communications support will be provided by the Deep Space Network.

(Budget Authority in Millions of Dollars)

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT •			36.4	19.8						56.2
MISSION OPS & DATA ANALYSIS				0.8	4.3					5.1
TOTAL			36.4	20.6	4.3					61.3

• Lunar Prospector development funding includes launch vehicle.

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, the Mars Global Surveyor mission, was approved as a new start in FY 1994. The follow-on Mars Surveyor 98 Orbiter and Lander were approved in FY 1995. 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 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 costs for 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)

Mars Surveyor Program	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
MARS GLOBAL SURVEYOR	14.8	80.0	78.7	32.5	19.9	10.6				236.5
98 MARS ORBITER/LANDER			63.5	103.5	70.1	40.2	21.7	15.3		314.3
FUTURE MISSIONS		1.4	1.4	3.1	54.9	119.8	141.1	158.5	Cont	480.2
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	14.8	81.4	143.6	139.1	144.9	170.8	162.8	173.8		1,031.0
(ESTIMATED CIVIL SERVICE FTEs)	(10)	(27)	(17)	(9)	(4)	(4)	(4)	(4)	(Cont.)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.7	1.9	1.2	0.7	0.3	0.3	0.3	0.4	Cont	

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 failure.

(Budget Authority in Millions of Dollars]

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
MARS GLOBAL SURVEYOR										
DEVELOPMENT	14.6	58.0	58.2	9.4						140.2
MISSION OPS & DATA ANALYSIS				16.4	19.6	10.4				46.4
LAUNCH SUPPORT		21.8	20.1	6.4						48.3
TRACKING & DATA SUPPORT	0.2	0.2	0.4	0.3	0.3	0.2				1.6
TOTAL	14.8	80.0	78.7	32.5	19.9	10.6				236.5

98 Mars Orbiter/Lander

The 98 Mars Orbiter and Lander are the first follow-on missions in the Mars Surveyor program. The Orbiter will be launched on a Med-Ute launcher In December 1998. and the Lander will be launched on a Med-Ute In January 1999. Lockheed Martin Aerospace, Denver, was selected competitively to develop these spacecraft. The Orbiter will carry a color Imager and a Pressure Modulater Infrared Radiometer (PMIRR), which was also a Mars Observer payload. The Lander will carry a descent Imager, a comprehensive volatiles and climate payload, and a Russian *LIDAR* atmospheric instrument.

(Budget Authority in Millions of Dollars]

	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	*TOTAL*
DEVELOPMENT			52.3	77.5	40.5	13.3				183.6
MISSION OPS & DATA ANALYSIS						10.3	21.3	15.0		46.6
LAUNCH SUPPORT			11.2	26.0	29.6	16.4				83.2
TRACKING & DATA SUPPORT						0.2	0.4	0.3		0.9
TOTAL			63.6	103.6	70.1	40.2	21.7	16.3		314.3

New Millennium Spacecraft

The New Millennium program is a partnership between the Space Science and Space Access and Technology programs. This advanced development effort started in FY 1996 to demonstrate how complex scientific spacecraft--such as those required for planetary missions--can be built for lower mission costs and 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 time frame.

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, beginning in 1998. Launches *arc* targeted for a small expendable launch vehicle. The budget estimate below does not include the costs for the government facilities and general and administrative support used to cany 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.

(Budget Authority in Millions of Dollars)

New Millennium Spacecraft	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
ADVANCED TECHNOLOGY DEVELOPMENT		10.5								10.5
DEVEIDPMENI'			30.0	21.5	54.9	51.4	43.9	40.3		Cont.
LAUNCH SUPPORT			11.7	12.0	7.9	10.7	14.8	10.3		Cont.
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		10.6	41.7	33.5	62.8	62.1	58.7	50.6		518.8
(ESTIMATED CIVIL SERVICE FTEs)		(1)	(1)	(1)	(1)	(1)	(1)	(1)	(Cont.)	
CML SERVICE COMPENSATION ESTIMATE ($M)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	Cont.	

Earth Observing System

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 Europe (ESA), Canada, and Japan both in terms of spacecraft and instruments. This extraordinary collaboration is essential to reach the objective of providing long-term (15 years). 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 $18-21 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 bufld-to-cost approach for the first unit of a multiple instrument bufld. 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.

In the FY 1996 budget process, the amounts reflected the related program costs for Landsat-7's activities previously funded by the Department of Defense.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The amounts below reflect the effects of the rescoping of the EOS program. the impacts of the ZBR, and the inclusion of the estimate for FY 2001. They do not include the costs of the non-program-unique government facilities and general and administrative

support used to carry out the research and development activities. A more detailed descrlption of the program goals, objectives and activities is provided in the speciflc budget justification narrative for the program within the Mission to Planet Earth section.

(Budget Authority in Millions of Dollars)

Earth Observing System	PRIOR	1995	1996	1997	1998	1999	2000	2001	TOTAL
MORNING SERIES	584.1	259.8	170.0	84.7	92.7	73.2	143.8	188.8	1,597.1
AFTERNOON SERIES	114.4	88.8	101.8	171.2	222.6	169.6	109.6	144.2	1,122.2
CHEMISTRY	11.8	10.3	27.3	77.4	106.4	147.1	181.5	145.8	707.6
SPECIAL SPACECRAFT	60.9	81.7	71.7	66.7	63.5	78.1	96.4	77.5	596.5
NEW MILLENNIUM PROGRAM - MISSION TO PLANET EARTH		1.0	10.0	10.0	15.0	15.0	15.0	15.0	81.0
LANDSAT 7 DEVELOPMENT	106.6	77.4	78.8	73.9	47.1	7.6	1.5		392.9
ALGORITHM DEVELOPMENT	139.6	55.1	75.7	101.8	142.8	150.3	178.3	156.0	999.6
EOSDIS	433.0	220.6	241.2	261.1	276.6	307.5	309.7	283.3	2,333.0
SUBTOTAL	1,450.4	794.7	776.5	846.8	966.7	948.4	1,035.8	1,010.6	7,829.9
PHASE B	41.0								41.0
SPACE STATION PLATFORM	104.0								104.0
TRACKING AND DATA SUPPORT			0.7	1.3	2.3	1.1	0.7	0.4	6.5
EOS SCIENCE	[77.7]	37.3	56.5	47.5	55.8	62.6	72.4	74.1	406.2
NEW MILLENNIUM PROGRAM - SPACE ACCESS & TECHNOLOGY			10.0	25.0	25.0	25.0	25.0	25.0	135.0
LAUNCH SERVICES	21.5	43.1	93.9	107.2	107.0	43.6	48.5	67.9	532.7
CONSTRUCTION OF FACILITIES	62.7	17.0	17.0						96.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	1,679.6	892.1	954.6	1,027.8	1,156.8	1,080.7	1,182.4	1,178.0	9,152.0
(ESTIMATED CIVIL SERVICE FTEs)	(1,489)	(579)	(629)	(799)	(821)	(771)	(755)	(739)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	92.1	41.2	44.7	60.1	65.8	63.9	64.7	64.9	

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. The Earth System Science Pathfinder 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 The Experiments of Opportunity funding will accommodate opportunities to provide flight instruments and technologies on non-Mission to Planet Earth missions. foreign or domestic, or on airborne experiments

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 work force 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 speciflc budget justification narrative for the program within the Mission to Planet Earth section.

(Budget Authority in Millions of Dollars)

Earth Probes	PRIOR	1995	1996	1997	1998	1999	2000	2001	TOTAL
SCATTEROMETER	191.4	15.4	7.7						214.5
TROPICAL RAINFALL MEASURING MISSION (TRMM)	151.0	51.3	24.2	20.9					247.4
TOTAL OZONE MAPPING SPECTROMETER (TOMS)	74.5	14.9	8.5	6.4	11.8	7.0	4.8	4.8	132.7
EARTH SYSTEM SCIENCE PATHFINDERS			1.0	20.0	30.0	75.0	75.0	75.0	Continues
EXPERIMENTS OF OPPORTUNITY			4.6	3.6	0.8	4.6	6.5		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-11 launch vehicle in August 1996.

(Budget Authority in Millions of Dollars)

Scatterometer	PRIOR	1995	1996	1997	1998	1999	2000	2001	TOTAL
DEVELOPMENT	191.4	15.4	7.7						214.5
MO & DA			2.4	13.0	6.7	3.1			25.2
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	191.4	16.4	10.1	13.0	6.7	3.1			239.7
(ESTIMATED CIVIL SERVICE FTEs)	(4)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	

Total Ozone Mapping Spectrometer

The TOMS Earth Probes program is a follow-on to the Total Ozone Mapping Spectrometer (TOMS) instrument flown with such great success on the Nimbus-7 spacecraft in 1978. A TOMS 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-1996 on a Pegasus launch vehicle. Flight model 3 will be flown on the TOMS Earth probe spacecraft. Flight model 4 is planned for launch on the Japanese ADEOS spacecraft in August 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)

Total Ozone Mapping Spectrometer	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
DEVELOPMENT	74.5	14.9	8.5	6.4	11.8	7.0	4.8	4.8		132.7
MO & DA	5.5	3.7	3.3	2.5	2.6	2.5	2.7	1.7	2.1	26.6
SELV	16.7									16.7
TRACKING (TOMS EARTH PROBE)	3.9	0.5	0.7							5.1
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	100.6	19.1	12.6	8.9	14.4	9.6	7.6	8.6	2.1	181.1
(ESTIMATED CIVIL SERVICE FTEs)	(112)	(14)	(11)	(6)	(5)	(5)	(5)	(4)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	6.9	1.0	0.8	0.5	0.4	0.4	0.4	0.4		

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 Niño 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-11 launch vehicle. The EOS Data and Information System will have a specific capability for disseminating TRMM 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	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
Tropical Rainfall Measuring Mission										
DEVELOPMENT	151.0	51.3	24.2	20.9						247.4
EOS-FUNDED	[8.6]	19.41	121.91	110.31	[8.8]	[12.6]				[71.6]
INSTRUMENTS/SCIENCE/DIS MISSION SCIENCE TEAMS &				6.0	5.8	4.4	4.5			20.7
MISSION GUEST INVESTIGATORS MO & DA				4.9	19.7	20.8	22.0	21.8	16.8	106.0
SCIENCE	18.7	4.9	5.9	5.9						35.4
TRACKING	4.8	3.7	2.8	2.2	1.1					14.6
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	174.6	69.9	32.9	39.9	26.6	25.2	26.5	21.8	18.8	424.1
(ESTIMATED CIVIL SERVICE FTEs)	(379)	(165)	(134)	(120)	(13)	(2)	(2)	(2)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	24.2	11.7	9.5	9.0	1.0	0.2	0.2	0.2		

TDRS Replenishment Spacecraft Program

The Tracking and Data Relay Satellite (TDRS) Replenishment Spacecraft program was initiated in response to reliability assessments indicating that a sufficient number of TDRS may not be available by the end of the decade. This program will provide for three additional TDRS spacecraft and ground modifications. A firm fixed price contract was awarded to Hughes Space and Communications Company in February 1995. However, initiation of development was delayed until July 1995, when a protest of the award was resolved by the Government Accounting Office. The spacecraft development is now underway, with the first spacecraft launch readiness scheduled for the third quarter of CY 1999.

The budgetary estimates provided below cover the design, development and launch of three spacecraft and are included in the Mission Support appropriation. FY 1995 and FY 1996 Operating Plan funding adjustments are reflected. The estimates do not include costs for the use of government facilities and general and administrative support used to *cany* out the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification for the program within the Office of Space Communications section.

(Budget Authority in Millions of Dollars)

TDRS Replenishment Spacecraft Program	PRIOR	1995	1996	1997	1998	1999	2000	2001	Balance	TOTAL
SPACECRAFT DEVELOPMENT AND GROUND TERMINAL MODIFICATIONS	2.6	45.0	147.2	162.1	117.8	75.3	38.5	9.4	12.3	610.2
MUNCH SERVICES		0.5	3.2	17.9	39.7	45.1	19.5	60.6	140.0	326.5
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	2.6	46.6	150.4	180.0	167.6	120.4	58.0	70.0	162.3	936.7
(ESTIMATED C M L SERVICE FTEs)	(14)	(15)	(33)	(35)	(37)	(39)	(36)	(35)		
C M L SERVICE COMPENSATION ESTIMATE ($M)	1.0	1.1	2.3	2.6	3.0	3.2	3.1	3.1		

Tra ; 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 a functionally-identical, nearly design-identical spacecraft to the initial TDRS constellation. 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 was accomplished in August 1995.

The budgetary estimates provided below cover the design and development phase as well as Shuffle launch costs. The Spacecraft Development and Launch Services for the Inertial Upper Stage are included under the Mission Support appropriation, and the Shuttle program costs are included in the Human Space Flight appropriation. Funding adjustments in FY 1995 associated with the FY 1996 Operating Plan are reflected. The estimates do not include costs for the use of government facfflties 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	1995	1996	1997	1998	1999	2000	2001	TOTAL
Tracking and Data Relay Satellite Replacement Spacecraft Program									
SPACECRAFT DEVELOPMENT	347.8	17.2							365.0
LAUNCH SERVICES (IUS)	81.1	15.6							96.7
MUNCH SUPPORT (STS)		469.6							469.6
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	428.9	502.4							931.3
(ESTIMATED CIVIL SERVICE FTEs)	(98)	(20)	(1)						
CIVIL SERVICE COST ESTIMATE ($M)	5.5	1.4	0.1						

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. Danzante is operational, supporting all user spacecraft. The White Sands Ground Terminal (WSGT), Cacique, is currently being refurbished and is scheduled to return to operational status in May 1996.

A funding reduction of $0.2M associated with the FY 1996 Operating Plan is reflected. The budgetary estimates provided below are the amounts included in the Mission Support appropriation for this program. The estimates do not include costs for 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	1995	1996	1997	1998	1999	2000	2001	TOTAL
Second TDRS Ground Terminal/White Sands Ground Terminal Upgrade Program									
DEVELOPMENT	556.1	18.6							574.7
COMMUNICATIONS	2.8								2.8
CONSTRUCTION OF FACILITIES	23.2								23.2
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	582.1	18.8							600.7
ESTIMATED CIVIL SERVICE FTEs	(138)	(15)	(9)	(5)	(1)	(1)	(1)	(1)	
CIVIL SERVICE COST ESTIMATE ($M)	8.1	1.1	0.6	0.4	0.1	0.1	0.1	0.1	

Human Space Flight

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 1997 ESTIMATES

GENERAL STATEMENT

GOAL STATEMENT

The Human Space Flight program is integral to the NASA enterprise for the Human Exploration and Development of Space (HEDS), which has as its ultimate mission to open the space frontier by exploring, using and enabling the development of space. Our current programs provide safe, assured transportation to and from space for people and payloads, and to develop and operate habitable space facilities, in order to enhance scientific knowledge, support technology development, and enable commercial activity. The four major goals of the Human Space Flight program are the following:

- Increase human knowledge of nature's processes using the space environment
- Explore and settle the solar system
- Achieve routine space travel
- Enrich life on Earth through people living and working in space

STRATEGY FOR ACHIEVING GOALS

In Human Space Flight, we are committed to ensuring effective, efficient and safe transportation to and from space, while continually seeking to improve the safety margin of the Space Shuttle. We are actively probing our process in order to reduce operational costs, improve performance on development projects and to selectively enhance capabilities to meet customer needs.

As we expand our capabilities for allowing humans to live and work continuously in space, we will transition from Spacelab to the conduct of joint space activities with Russia at Mir, assemble International Space Station, and then accomplish the development, operation, and utilization of the International Space Station on schedule and within budget.

Human Space Flight, through the utilization of Space Shuttle, Spacelab and Space Station, provides the capabilities to enable the development of advanced space systems, technologies, and materials. In meeting these capabilities, we will ensure that our workforce, our most important resource, will have management support to meet operational and future program requirements through career development training and employee recognition programs.

Recognizing the national benefits derived from past space activities, we will continue to emphasize Human Space Flight's contribution to the national community. These contributions will be implemented by contributing to science and engineering educational opportunities for our youth, by enhancing U.S. competitiveness in the world and in space though support of collaborative relationships with industry and by improving the nation's quality of life by making advanced technology, directly and through "spinoffs", available to the private sector.

Human space flight achievements in exploration and development of space have paved the way for enhancing our nation's leadership in expanding the human presence in space. The necessity to fly safely and the requirement to satisfy customer needs along with pressure to reduce operations costs will be the dominant programmatic thrusts throughout the next decade. Our success in achieving Human Space Flight goals and objectives will play a central role in leading our Nation to future technological advances for humans as they further expand their presence in space.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT
FISCAL YEAR 1997 BUDGET ESTIMATES
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1995	1996	1997
HUMAN SPACE FLIGHT	**5,514.9**	**5,456.6**	**5,362.9**
SPACE STATION	1,889.6	1,863.6	1,802.0
RUSSIAN COOPERATION	150.1	129.2	138.2
SPACE SHUTTLE	3,155.1	3,148.8	3,150.9
PAYLOAD AND UTILIZATION OPERATIONS	320.1	315.0	271.8

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 space 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, $5,362,900,000 to remain available until September 30, 1998.

Note.—A regular 1996 appropriation for this account had not been enacted at the time this budget was prepared. The 1996 amounts included in this budget are based on the levels provided in three continuing resolutions: P.L. 104–91, P.L. 104–92 and P.L. 104–99.

NATIONAL RONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT
REIMBURSABLE SUMMARY
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1995	1996	1997
HUMAN SPACE FLIGHT	**81.6**	**97.4**	**108.2**
SPACE STATION	0.1	--	--
SPACE SHUTTLE	49.5	44.1	53.3
PAYLOAD UTILIZATION AND OPERATIONS	32.0	53.3	54.9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1997 ESTIMATES

DISTRIBUTION OF HUMAN SPACE FLIGHT BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	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	1995	1,889,600	1,716,837	84,260	56,808	0	0	0	1,521	17,000	150	15	13,009
	1996	1,863,600	1,737,800	47,600	66,100	0	0	0	0	7,000	100	0	5,000
	1997	1,802,000	1,638,600	70,300	81,800	0	0	0	400	5,000	100	0	5,800
U.S.-Russian Cooperative Program	1995	150,100	140,900	7,100	1,900	0	0	0	0	200	0	0	0
	1996	129,200	125,800	900	0	0	0	0	0	0	0	0	2,500
	1997	138,200	115,200	1,500	0	0	0	0	0	0	0	0	21,500
Space Shuttle	1995	3,155,100	869,500	835,000	1,351,600	49,400	0	6,100	0	0	0	0	43,500
	1996	3,148,800	953,600	812,900	1,302,500	45,400	0	5,600	0	0	0	200	28,600
	1997	3,150,900	879,800	799,700	1,387,800	50,900	0	5,400	0	0	0	0	27,300
Payload and Utilization Operations	1995	320,100	77,000	98,200	127,200	1,800	0	0	0	300	11,900	0	3,700
	1996	315,000	81,100	87,100	115,700	1,600	0	0	300	0	7,900	0	21,300
	1997	271,800	68,000	81,300	100,700	1,700	0	0	200	0	7,300	0	12,600
TOTAL HUMAN SPACE FLIGHT	1995	5,514,900	2,804,237	1,024,560	1,537,508	51,200	0	6,100	1,521	17,500	12,050	15	60,209
	1996	5,456,600	2,898,300	948,500	1,484,300	47,000	0	5,600	300	7,000	8,000	200	57,400
	1997	5,362,900	2,701,600	952,800	1,570,300	52,600	0	5,400	600	5,000	7,400	0	67,200

Space Station

HUMAN SPACE FLIGHT

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE STATION**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	Page Number
		(Thousands of Dollars)		
Development	1,749,400	1,696,200	1,513,200	HSF 1-4
Utilization support	31,300	47,400	72,100	HSF 1-13
Operations	108,900	120,000	216,700	HSF 1-17
Total	1,889,600	1,863,600	1,802,000	
Distribution of Program Amount by Installation				
Johnson Space Center	1,716,837	1,737,800	1,638,600	
Kennedy Space Center	84,260	47,600	70,300	
Marshall Space Flight Center	56,808	66,100	81,800	
Langley Research Center	1,521	--	400	
Lewis Research Center	17,000	7,000	5,000	
Goddard Space Flight Center	150	100	100	
Jet Propulsion Laboratory	15	--	--	
Headquarters	13,009	5,000	5,800	
Total	1,889,600	1,863,600	1,802,000	

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 international 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 the capability to stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge.

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 invitation to the Russians to enter into the international partnership.

The Space Station will be developed within an annual funding constraint 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, and research and experiment development, and are funded in those programs' respective budgets. The estimate for completing the development and assembly of the Space Station is unchanged: $17.4 billion (from FY 1994 through June 2002), including $14.6 billion for developing and operating the Station, $0.2 billion for Space Shuttle-Mir activities, and $2.6 billion for science payload facilities and utilization. The total cost estimate and schedule are contingent upon annual funding levels of $2.1 billion for the activities described above. This funding level reflects the Agency's 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 $5 billion for design and development, and anticipate a total expenditure of nearly $10 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.

The International Space Station is being built and operated through three phases of development. Phase I is currently underway and includes nine Shuttle-Mir docking missions. The goals of the Phase I program are to develop and demonstrate joint mission procedures with Russia, gain valuable experience to reduce technical risk during International Space Station construction, and provide early opportunities for extended scientific research. The Mir missions have been increased from seven to nine in order to provide for extended Mir operations. The Office of Space Flight phase I effort is funded primarily in the U.S./Russian cooperative budget.

Phase II begins with launch of the U.S.-owned/Russian-launched functional cargo block (FGB) in November 1997. Permanent crew capability for three persons will be available upon delivery of the Soyuz in May 1998. Microgravity capability will be available in December 1998 with the outfitting of the U.S. laboratory. At this stage, the Station configuration will include the U.S. node, laboratory, power and mini-pressurized logistics module (MPLM); Russian life support, crew accommodations, propulsion, research module, and crew return; and the Space Station remote manipulator system (SSRMS), provided by Canada.

Phase III will begin with delivery of the airlock and truss elements. Six additional utilization flights, delivery of the centrifuge, and external payload sites will provide science and research accommodations. Integration of the international modules, including the Japanese Experimental Module (JEM), European Columbus Orbital Facility (COF), Russian research modules, plus the U.S. habitation module in February 2002 will complete the pressurized volume space and crew accommodations. Delivery of the crew rescue vehicle and the final outfitting flight will mark assembly completion of the International Space Station, and permanent 6-member crew capability. At the completion of this stage, the configuration will include a second U.S. node, habitation module, truss elements and solar arrays; international laboratory and research modules, centrifuge module, solar arrays and resupply/support vehicles. ESA has proposed delay of the launch of the COF until after permanent 6-member crew capability is achieved.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACE STATION DEVELOPMENT

	FY 1995	FY 1996 (Thousands of Dollars)	FY 1997
Flight hardware	1,319,900	1,413,300	1,244,400
Test, manufacturing and assembly	91,900	68,600	78,200
Operations capability and construction	169,800	117,100	111,300
Transportation support	117,600	74,100	76,100
Flight technology demonstrations	30,000	8,300	3,200
Subtotal	1,729,200	1,681,400	1,513,200
Operations capability and construction			
Neutral buoyancy laboratory - CofF	20,200	14,800	--
Total	1,749,400	1,696,200	1,513,200

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, unpressurized logistics carriers and a centrifuge accommodation module. 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 pressurized logistics modules, 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 is providing experiment, power, life support, and service modules, Soyuz crew transfer vehicle, and universal docking modules.

Boeing has been awarded the prime contract for the Space Station, including accountability for integration and assembly of the International Space Station. 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. Additionally, McDonnell Douglas will provide major components of the communications and data handling, thermal control, and the guidance, navigation and control subsystems.

U.S. pressurized volumes are being 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 currently manifested for flight during October 1999. The final U.S. pressurized volume is the habitation module which will contain the galley, wardroom, 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, rotary joint, radiator, arrays and associated power storage and conditioning elements make up the power system.

A request for proposal was released in November 1995 for a centrifuge accommodation module to be mounted on the zenith port of node 2. It will provide accommodation for the centrifuge and additional stowage for experiments and Space Station systems. Launch is scheduled for August 2001.

The development program also includes test, manufacturing and assembly support for critical NASA center activities and institutional support. These "in-line" products and services include: test capabilities; the provision of government-furnished equipment (GFE), including flight crew systems, communications and tracking, and EVA equipment; and engineering analyses. As such, they 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 pre-launch 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.

The redesigned Space Station emphasizes multicenter and multiprogram cooperation. At JSC, a consolidated approach between Space Shuttle and Space Station will minimize 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.

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, flown during Phase I, 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 change in the logistics requirements for Mir caused a flight cancellation of the solar dynamic technology demonstration payload that was being developed jointly with RSA, and which was co-funded with the Office of Space Access and Technology.

MEASURES OF PERFORMANCE

Completed Technical Convergence Review November 1994 (on plan)	Technical review to assurance that vehicle design baseline is consistent with engineering and contractual documentation, feasible with acceptable development risk, safe, operable, and supports utilization.
Completed Joint Program Review (Moscow) November 1994 (on plan)	First in a series of top level [illegible]s of NASA/RSA cooperative effort; [illegible]firmed program milestones for 1995 and beyond.
Definitized Boeing Contract January 1995 (on plan)	Finalization of NASA-Bo[illegible]ng agreement; established con[illegible]t[illegible] baseline, cost arrangement for Space Station.

Completed Incremental Design Review March 1995 (on plan) Perform IDR #2 March 1996 Perform IDR #3 March 1997	First in a series of incremental, cumulative reviews throughout the design phase to 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. IDR #1 performed these functions for flights 1A through 6A.

Prime Development Activity

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

Flight 1A: (November 1997) FGB Energy Block (First Element Launch) (Proton Launch Vehicle)	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 Y 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)
- Complete flight software (1st Qtr FY 1997)
- Complete solar array compartment test (2nd Qtr FY 1997)
- Deliver FGB flight article to Baikanour (3rd Qtr FY 1997)
- Complete factory ground testing of first flight unit (3rd Qtr FY 1997)

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 (STA) (1st Qtr FY 1996)
- Complete node STA proof pressure/leak rate qualification testing (2nd Qtr 1996)
- Complete node STA 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 installation of mechanical equipment into Node 1 flight article primary structure

(4th Qtr FY 1996)

- Complete design and fabrication of Node 1 flight article 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 (1st Qtr FY 1997)
- Complete PMA-2 design (4th Qtr FY 1996)
- Complete PMA-1 & 2 acceptance test (3rd Qtr FY 1997)
- Complete Node 1 acceptance test (3rd Qtr FY 1997)
- Node 1 on dock at KSC (4th Qtr FY 1997)

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 (2nd Qtr FY 1996)
- Begin fabrication and assembly of Z1 truss (2nd Qtr FY 1996)
- Complete design of 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 (2nd Qtr FY 1996)
- PMA-3 pressurized shell & secondary structure on-dock at McDonnell Douglas for tooling & fabrication (2nd Qtr FY 1996)
- Z1 fabrication and assembly complete (2nd Qtr FY 1997)
- Begin flight article CMG acceptance test (2nd Qtr FY 1997)
- PMA-3 on-dock at KSC (4th Qtr FY 1997)

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 long spacer qualification unit design (2nd Qtr FY 1996)
- Begin fabrication and assembly of P6 truss segment qualification unit (3rd Qtr FY 1996)
- Complete assembly of P6 integrated electronics assembly (IEA) qualification unit (1st Qtr FY 1996)
- Complete mechanical installation and outfitting of IEA qualification unit (4th Qtr FY 1996)

- Complete IEA qualification unit hardware/software integration and functional testing (1st Qtr FY 1997)
- Begin thermal vacuum testing of IEA qualification unit (2nd Qtr FY 1997)
- Begin P-6 long spacer flight hardware fabrication/assembly (1st Qtr FY 1997)
- IEA structural framework procurement for PV-1 complete (3rd Qtr FY 1997)
- Complete flight qualification IEA testing (4th Qtr FY 1997)

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 (4th Qtr FY 1996)
- Complete development of lab flight article pressure vessel (4th Qtr FY 1996)
- Standoff endcones - Design complete (4th Qtr FY 1996)
- ISPR outfitting kit procurement complete (2nd Qtr FY 1997)
- Complete lab racks, crew systems, closeouts, and hatch installation (4th Qtr FY 1997)

Flight 6A: (December 1998)
Mini-Pressurized Logistics Module,
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)
- Complete lab storage rack test (3rd Qtr FY 1997)
- Deliver SSRMS to NASA (2nd Qtr FY 1997)
- Complete MPLM FM1 structure manufacturing and [illegible] (3rd Qtr FY 1997)

<u>Non-Prime Development Activity</u>

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) This activity and measure of performance have been transferred to the Life and Microgravity Sciences and Applications program.
Flight Crew Systems	Provides flight and training hardware and provisions for food and food packaging development; housekeeping management; portable breathing apparatus; restraints and mobility aids, tools and diagnostic equipment and portable illumination kit 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) • Complete production of tools and diagnostic flight hardware kit (4th Qtr FY 1997) • Complete CDR for portable illumination (4th Qtr FY 1997)
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	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) • Training capability to support flight 2A (3rd Qtr FY 1997)
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) SVF integration test for flights 2A-4A (2nd Qtr FY 1997)

Neutral Buoyancy Laboratory (NBL)	Provides training tank facility for neutral buoyancy training capability at the Sonny Carter Training Facility • Complete training tank construction (3rd Qtr FY 1996)

ACCOMPLISHMENTS AND PLANS

During FY 1995, prime negotiations with Boeing were carried out, with definitization completed in January. Agreements between the prime and first tier subcontractors are nearing completion, and are expected to be finalized shortly. Negotiations on the NASA/Russian Space Agency (RSA) Memorandum of Understanding (MOU) on Space Station are ongoing and work has continued with the other partners to renegotiate MOUs to reflect Russian participation.

Major technical activities were completed, including: Preliminary Design Reviews (PDR) for the Z-1 truss/P-6 spacer, joint airlock structure, and mini pressurized logistics module (MPLM); and Critical Design Reviews (CDR) for the FGB, software verification facility, and pressurized mating adapters (primary structures). Qualification testing of major electrical power system components continued, the weightless environment test facility test of the S1 truss/radiator orbital replacement unit (ORU) was completed, and qualification testing of the pressurized mating adapter (PMA) 2 weld was initiated. Incremental Design Review (IDR) #1 provided a system level PDR for flights 1A - 6A and produced a significant level of Russian participation in program integration and assessment.

Production of flight hardware continued in earnest during FY 1995. Boeing completed the primary structure for the node structural test article (STA), node 1, and U.S. laboratory; rack structures assemblies, the common module mid-cylinder, and laboratory panels; and delivered the first two international standard payload racks (ISPR). Rocketdyne produced hardware includes several elements of the solar power module including the solar array mast, the radiator panel, solar array panels, the beta gimbal assembly, and the pump flow and control subassembly. McDonnell Douglas has assembled the pressurized mating adapter mockup, segment SO and S1 mockups, and the node structural test article detailed parts and subassemblies.

In the operations capability development area, construction of the neutral buoyancy laboratory (NBL) began at the Sonny Carter Training Facility, with completion targeted to support training activity for first element launch (FEL) in November 1997.

FY 1996 will see continued qualification testing, and manufacture of flight hardware as the program readies for FEL in November of FY 1997. IDR #2 will perform a CDR for flights 1A through 6A and a PDR for flights 6R-12A in the spring. International efforts will continue with closure of the NASA/RSA MOU on Space Station and renegotiation of MOUs with ESA, Japan, and Canada to reflect Russian participation. The ESA Ministerial Council will meet to finalize ESA participation in Station and all partners continue development of flight hardware. The Columbus orbital facility (COF) will perform PDR, the Japanese experimental module (JEM) will undergo CDR #1 and the Space Station remote manipulator system (SSRMS) will finish final integration.

Power system qualification tests will be completed throughout the year, including the battery charge/discharge unit (BCDU), Type II remote power connectors (RPC), main bus switching unit (MBSU), direct current switching unit (DCSU), external and internal DC-to-DC converter units, and the pump and flow control subassembly (PFCS). The integrated electronics assembly (IEA) qualification unit hardware/software integration and functional testing will be complete.

The joint airlock will undergo CDR early in the year, followed by welding and mechanical installation. The Z1 truss will complete CDR and begin fabrication and assembly. Flight hardware production will begin on all three pressurized mating adapters and the S0 truss segment, in addition to the truss segment S1 structural test article (STA). The PMA 2 weld qualification test will be completed along with hatch and antenna qualification testing. Final assembly and outfitting of all major components of the node 1 flight article will begin, as well as the common module structural test article. Control moment gyros (CMGs) qualification unit build will be completed and flight article builds will commence.

During FY 1997 the major program focus will be manufacturing and testing flight hardware to support FEL in November of 1997 and subsequent launches throughout early 1998. Major preparation will be made in support of the FGB, node 1, truss segments, the U.S. laboratory, and the subsystems to support these elements. The international partners will continue development of flight hardware with the FGB flight article assembly completion and delivery to Baikanour, the start of the SSRMS performance test, and the JEM CDR 2.

U. S. efforts include the node STA qualification test complete, the node 1 acceptance test completion and delivery of the node 1 to KSC the last quarter of FY 1997. Control moment gyros (CMGs) qualification test, Z1 truss static test, control and data handling (C&DH) formal stage test, and integrated electronics assembly (IEA) acoustic tests will also be performed.

Integration of node 1 and PMA 1 and 2 will occur during FY 1997. The Z1 truss fabrication and assembly, CMGs flight article fabrication and the IEA structural framework fabrication are to be completed before the end of the fiscal year. The MPLM will undergo CDR and the primary structure will be manufactured and assembled. Installation of lab endcone hardware, racks and hatches will begin.

BASIS OF FY 1997 FUNDING REQUIREMENT

UTILIZATION SUPPORT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
User support.	31,300	47,400	72,100

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. 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 capability 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 International 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. 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 station-wide level.

MEASURES OF PERFORMANCE

Delivered first and second TASP units 3rd & 4th Qtr FY 1995 (on plan)	Test & simulation processor (TASP) is used to verify the payload data services system (PDSS) software in a real-time flight simulated environment.
Completed Phase 1 & 2 of the POIC/USOC integrated system 3rd Qtr FY 1995 (on plan) (Final Phase 5 complete 1st Qtr FY 1998)	POIC/USOC systems provide real-time support to International Space Station payloads including: communications, voice, video, data systems, and facility services.
Deliver and integrate final front end processors into PDSS 4th Qtr FY 1996	The payload data services system (PDSS) provides the data handling software and network needed to distribute data from the TDRSS users at the POIC/USOC and other remote facilities. The front end processor unit is a key element in the reception of data from TDRSS.
Deliver first STEP production unit 4th Qtr FY 1996	Suitcase test environment for payloads (STEP) enables the verification of the payload to rack interface at remote payload development sites.
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 reception, system 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.
Transition POIC/USOC and PDSS development to consolidated Utilization Mission Support contract 3rd Qtr FY 1996	Payload operations and integration center (POIC) and U.S. operations center (USOC) and PDSS will gain efficiencies in development effort by a single contractor.

Begin manufacturing of lab support equipment cold storage units 3rd and 4th Qtr FY 1996	The refrigerator/freezer, "quick snap" portable cold storage unit, and cryogenic freezer will be used for life and materials experiments in the U.S. Lab. This activity and measure of performance have been transferred to the Life and Microgravity Sciences and Applications program.
Complete UF-1 baseline IDRD 2nd Qtr FY 1997	The interface definition and requirements document (IDRD) describes the on-orbit resources (volume, power, data, etc.) allocated to all payloads.
Complete lab support equipment glovebox manufacturing 4th Qtr FY 1997	General purpose glovebox workstation for non-biological experiments in U.S. Lab module. This activity and measure of performance have been transferred to the Life and Microgravity Sciences and Applications program.
Complete lab support equipment cryogenic freezer manufacturing 4th Qtr FY 1997	Provides additional cold-storage volume for experiments in the U.S. Lab. This activity and measure of performance have been transferred to the Life and Microgravity Sciences and Applications program.
Complete all POIC/USOC and facilities outfitting 4th Qtr FY 1997	Includes workstation upgrades in payload operations integration center (POIC) and U.S. operations center (USOC) at MSFC.
HOSC annex operational readiness date 3rd Qtr FY 1997	Huntsville operations support center (HOSC) annex supports distribution of downlinked payload data to remote user locations.

ACCOMPLISHMENTS AND PLANS

During FY 1995, the PDSS development began and will be completed in FY 1998. The POIC/USOC integrated system, completed the first two phases of a five-phase development. Also in FY 1995, the incremental operations preparation and payload analytical integration began for the first utilization flights. During FY 1995, the Utilization, Operations and Training Assessment Team (UOTAT) reviewed current requirements and implementation plans for utilization, operations and training in support of the International Space Station which resulted in projected cost savings of $65 million, which were incorporated in the utilization budget (FY 1995 through FY 2002).

During FY 1996, the design and development of the payload training capability at the Johnson Space Center (JSC) and the physical integration capability at the Kennedy Space Center (KSC) will be completed. Finalization of the payload ground system and facilities design will also occur in FY 1996. Other FY 1996 activities include qualification, fabrication and delivery of an EXPRESS rack to be flown on the Microgravity Science Lab. The PDSS design and development will be completed and integration

and testing will begin. The third and fourth phase of the five phase POIC/USOC system will be completed. A demonstration of the payload data library concept will occur in early FY 1996 and will be followed by the start of full-scale development with completion in FY 1997. The payload rack checkout unit (PRCU) will begin development in FY 1996 and is also scheduled for completion in FY 1997. Selected lab support equipment items, were transferred in FY 1996 to the Life and Microgravity Sciences and Applications program.

In FY 1997, payload engineering of specific utilization flights will begin, including establishment of a template for each of the six utilization flights, operating plans and wiring diagrams. In mid FY 1997, payload training plans will be issued. All suitcase test environment for payloads (STEP) units will be complete and available for shipment to users and payload development sites in FY 1997. Payload utilization agreements (PUMA) will be baselined for UF-1 payloads. The second build of four for POIC/USOC data systems will be delivered.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACE STATION OPERATIONS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Vehicle operations	35,900	37,800	75,800
Ground and transportation operations	73,000	82,200	140,900
Total	108,900	120,000	216,700

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 began early in development. Streamlining and efficiencies with existing programs will be maximized as outlined in the recent Utilization, Operations and Training Assessment Team (UOTAT) exercise, which identified savings to the Station program.

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, configuration management, and any associated procurement activity.

Vehicle operations sustaining engineering will be performed by a small cadre of civil service system experts supported by a small number of sustaining engineering contractors. 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 continue to be minimized by the application of logistics support analysis to the design, resupply/return and spares procurement processes. Flight hardware spares and repair costs will continue to be reduced by establishing a maintenance and repair capability that effectively utilizes Kennedy Space Center (KSC) and 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 is composed of the Mission Control Center-Houston (MCC-H) and the Mission Control Center-Moscow (MCC-M) at Kaliningrad. The MCC-H will be the prime site for the planning and execution of integrated system operations of the Space Station. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite System (TDRSS) system and the Russian communication assets.

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 payload and systems training facilities and the concept of proficiency based learning will increase the efficiency of the overall training effort.

Operations support will provide analysis systems definition, development, and implementation to ensure that 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), photo/TV training, operations safety assessments, medical operations tasks, mission execution and systems performance assessment, and sustaining engineering.

Launch site processing begins prior to the arrival of the flight hardware at KSC with requirement definition and processing planning. Upon arrival at KSC, the flight hardware will undergo various processes, dependent upon the particular requirements for that processing flow. These processes may include: post delivery inspection/verification, servicing, interface testing, integrated testing, close-outs, weight and center of gravity measurement, and rack/component to carrier installation.

MEASURES OF PERFORMANCE

Issue first IDRD - Plan: December 1995 Actual: December 1995	The increment definition and requirements document (IDRD) defined the International Space Station program requirements for implementation by execution-level planning organizations, Shuttle integration activities, International Space Station/Russian Space Agency (RSA) integration activities, and NASA operations which are coordinated with RSA operations.
Issue first multi-increment manifest Plan: January 1996 Actual: January 1996	Provided the basis for all planning of assembly and utilization flights.
Update supportability assessment for IDRD #2 March 1996	Provides an executive summary and detailed information regarding on-orbit and ground organization ability to support International Space Station.

Baseline sustaining engineering implementation plan - June 1996	Details the roles and responsibilities of NASA and the prime contractor for sustaining the International Space Station hardware and software after delivery to NASA.
Demonstrate MCC-H to MCC-M command and telemetry support capability July 1996	Development of the Mission Control Center - Houston (MCC-H) to Mission Control Center-Moscow (MCC-M) command and telemetry capability necessary for the support of the Space Station flight vehicle.
Baseline International Space Station program implementation plan December 1996	Details the roles, responsibilities, and implementation plans for NASA and its international partners to support International Space Station operations.
KSC ground support equipment ready to support Flight 2A - April 1997	Completion of the design, manufacture, and activation/validation of KSC supplied ground support equipment for flight 2A will provide a basic processing capability to support all Station hardware flights.
Baseline mission integration plan for UF-1 May 1997	Required to define utilization flight (UF-1) mission requirements and payloads.
Complete MCC-H/SSTF integrated operations training capability May 1997	Supports the training schedule required to train ground crews for real-time operations of the Space Station vehicle.
Complete SSPF operational readiness June 1997	Completion of the installation and activation of the Space Station processing facility (SSPF) and facility systems. Provides the capability to support launch site processing of the KSC launched cargo elements.

ACCOMPLISHMENTS AND PLANS

At the beginning of FY 1995, the operations strategy for Phase I was completed. Throughout the year, operations provided support to station design and development teams to ensure safe and cost-effective operability of the International Space Station. The Mission Control Center-Houston (MCC-H) provided support to the May 1995 docking mission to Mir in the special vehicle operations room. Development of the Space Station training facility (SSTF) continued with two incremental deliveries and

completed U.S./Russian simulator development agreements. The SSTF will provide full-up MCC-H flight controller training and integrated ground crew training. Logistics and maintenance activities include provision for vehicle design evaluation in conjunction with the incremental design review (IDR-2) to ensure supportability during the operational time frame. Spares requirements, technical support data and maintenance procedures were developed. Also in FY 1995, the construction of facilities phase of the Space Station processing facility (SSPF) was completed. The Russian Space Agency's processing of the Mir docking module (Phase I hardware) became the first processing of flight hardware in the SSPF.

In FY 1996, funding will support MCC-M command and telemetry support capability and data/voice record and playback capability. The integrated planning system will have initial Station capability to support planning for first element launch. Supply, transportation, and site facilities support infrastructure required for spares and repairs will be provided in preparation for 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. Also in FY 1996, the International Space Station program planning is establishing integrated traffic and crew rotation plans for Phase 2 through the baseline of the multi-increment manifest. Program operational requirements are being established through increment definition and requirements documentation (IDRD). Utilization planning will be started with the receipt of program commitments for user resources.

In FY 1996 and FY 1997, work will continue on KSC launch site requirements definition, processing plans, and scheduling, as well as the development of ground support equipment and the test control and monitor system (TCMS). The SSPF and facility systems installation, activation, and validation will continue until the operational readiness date, which is set for June 1997.

In FY 1997, final preparations for first element launch will be reviewed through the increment integration review for Increment 1. Plans for the first utilization flight will be formally defined through approval of the Shuttle mission integration plan for UF-1. The SSTF and MCC-H will be ready to begin crew and ground controller training for flights 1A-4A. Also during FY 1997, the integrated planning system will be ready to support planning for the 1A-5A flights. The basic mission rules and operations data file for flights 1A-4A will also be produced.

US/Russian
Cooperative
Program

HUMAN SPACE FLIGHT

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

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

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996 (Thousands of Dollars)	FY 1997	Page Number
Russian space agency contract support	100,000	100,000	100,000	HSF 2-1
Mir support	50,100	29,200	38,200	HSF 2-1
Total	150,100	129,200	138,200	
Distribution of Program Amount by Installation				
Johnson Space Center	140,900	125,800	115,200	
Kennedy Space Center	7,100	900	1,500	
Marshall Space Flight Center	1,900	--	--	
Lewis Research Center	200	--	--	
Headquarters	--	2,500	21,500	
Total	150,100	129,200	138,200	

PROGRAM GOALS

The United States and the Russian federation have underway a joint cooperative space program to accomplish six major goals. First, the program permits 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 permits 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 (ISS) 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 advances U.S. national space programs as well as U.S. aerospace industry.

STRATEGY FOR ACHIEVING GOALS

The two major activities comprising the U.S./Russian cooperative program include the contract with the Russian Space Agency (RSA) which provides services and hardware for Phase I and selected Phase II activities related to the Space Station program, and conducting joint space activities with Russia on the Mir space station. Portions of Phase I and Phase II are conducted in parallel.

Phase I of the program 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 Russian Space Station and provides the potential for up to ten flights to Mir, including U.S. crew stays. Current NASA planning manifests nine Space Shuttle flights to Mir. Phase I provides valuable experience and test data which will greatly reduce technical risks associated with the construction and operation of the ISS and provide early opportunities for extended scientific and research activities. The Russian Space Station's capabilities will be enhanced by contributions from both countries. The Space Shuttle has delivered new solar arrays built by the Russians, one of which uses solar cells provided by the U.S., which replaced existing arrays on Mir. Russia has launched the Spektr module and will launch the Priroda module to its station, equipped with U.S., Russian, and other international scientific hardware to support science and research experiments. NASA has recently added an eighth and ninth shuttle flight to Mir in 1998. The additional flights are consistent with the Gore-Chernomyrdin Commission protocol signed on January 30, 1996. These additional flights will assist Russia in meeting its commitment to deliver, on schedule, key elements used in the early assembly of the ISS and will permit additional NASA astronauts to perform long-duration missions on Mir. The eighth and ninth Mir flights will use the Space Shuttle to temper a significant logistics shortfall on Mir, conduct vital engineering research and expand our knowledge and experience of the effects of long-duration weightlessness. In addition, these extended Mir operations will assist Russia in its objective to extend the Mir on-orbit lifetime through FY 1999. This approach takes into account the joint US/Russian interest in continuation of the Shuttle/Mir program, while minimizing changes to the ISS development plan.

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

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 which will assist in the design, development, operations, and utilization of the ISS.

During Phase I, the RSA will provide management, Mir lifetime extension, Mir capabilities expansion, docking hardware and mission support for both long-duration and short-term, joint 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, and propulsion systems documentation. 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 ISS. During this phase, the RSA will provide management, advanced technology, ISS elements, and associated analyses. Advanced technology includes joint development of ECLSS upgrades. ISS elements include requirements definition of a joint airlock and delivery of androgynous peripheral docking system (APDS) hardware, service module modifications, FGB energy block modifications, delivery of repress/depress pumps and study and documentation related to 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 ISS. From FY 1995 through FY 1998, NASA will fly nine missions to the Mir. The primary objectives of these flights are to rendezvous and dock with the Mir, perform on-orbit, joint U.S./Russian science and research, perform on-orbit joint operations, which will serve as a platform for future ISS operations, resupply Mir logistics, and rotate the American astronaut on-board Mir. The first of these flights employed a Spacelab long module to support experiment transport and operation, as well as the transport of Mir hardware. Eight other flights will require pressurized habitable modules to transport Russian logistics items, NASA and Russian science and technology payloads, and ISS risk mitigation payloads to Mir. Modules are being supplied for Flights 3,4,5 & 6 under a contract with Spacehab, Inc. No decision has yet been made regarding logistics carriers for subsequent flights.

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 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, Spacehab, Inc., Boeing, Rocketdyne, AlliedSignal, and Lockheed Martin.

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 the joint missions 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 ISS.

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 Plan: December 1994 Actual: December 1994	Design, fabrication, and test of hardware for Spektr launch of U.S. experiments.
Delivery of docking mechanism, Plan: 3rd Qtr FY 1995 Actual: June 1995	Docking mechanism, docking module and solar arrays to support flights to Docking module, and solar arrays.
Delivery of hardware for U.S. Priroda Plan: 4th Qtr FY 1995 Revised: 3rd Qtr FY 1996	Design, fabrication, test and installation of hardware for Priroda launch experiments on of U.S. experiments. [redacted] launch delay.

Launch of U.S. experiments on Priroda Plan: 4th Qtr FY 1995 Revised: 2nd Qtr FY 1996	Priroda launch will carry additional U.S. science experiments and equipment. Priroda launch delay.
Delivery of Solar Dynamics Qual Hardware Plan: 2nd Qtr FY 1996 Actual: Canceled	Delivery of qualification hardware for testing. The solar dynamics flight demonstration has been terminated.
Delivery of airlock depress/ repress pump assembly 3rd Qtr FY 1996	Delivery of flight article.
Delivery of passive docking mechanisms Plan: 3rd Qtr FY 1996 Revised: 3rd & 4th Qtrs FY 1996	Delivery of two passive docking mechanisms, associated avionics, control panels, and documentation to support Phase II Space Shuttle flights to the ISS
Delivery of Solar Dynamics Flight and GSE Hardware Plan: 1st Qtr FY 1997 Actual: Canceled	Delivery of flight article and associated ground support equipment. The solar dynamics flight demonstration has been terminated.
Delivery of docking mechanisms: 2nd, 3rd, and 4th Qtr FY 1997 and 1st Qtr FY 1998	Delivery of five docking mechanisms for Space Shuttle flights to Space Station with three sets of associated avionics.
<u>Mir Support:</u>	
Progress launched to Mir Plan: 2nd Qtr FY 1995 Actual: February 1995	Progress launch to Mir carried U.S. science experiments.
Astronaut launched on Soyuz Plan: 2nd Qtr FY 1995 Actual: March 1995	American astronaut launched on Soyuz to perform science investigations.

Spektr module launched to Mir - Plan: 3rd Qtr FY 1995 Actual: May 1995	Spektr launch carried additional U.S. science experiments and equipment.
Space Shuttle docking to Mir Plan: 3rd Qtr FY 1993 Actual: June 1995	STS-71 rendezvous was first docking flight to Mir with crew exchange.
Complete Spacehab primary structure Plan: 4th Qtr FY 1995 Actual: September 1995	Spacehab, Inc. completed manufacture of the primary structure for use on STS-76, STS STS-81, and STS-84.
Achieve six months of American crew time on Mir - 3rd and 4th Qtrs FY 1996	Conduct life sciences and microgravity research aboard Mir.
Spacehab pressurized module to Mir - 2nd and 4th Qtrs FY 1996	Transport Russian logistics items, U.S. and Russian science and technology payloads, and ISS risk mitigation payloads.
Joint EVA spacewalk on Mir - 4th Qtr FY 1996	Perform a joint U.S./Russian spacewalk to validate and demonstrate assembly techniques for the ISS.
Twelve months of American crew time on Mir - FY 1997	Conduct life sciences and microgravity research aboard Mir.
Joint EVA for Solar Dynamics - Plan: 4th Qtr FY 1997	The solar dynamics flight demonstration has been terminated.
Spacehab pressurized module to Mir - 1st and 3rd Qtrs FY 1997	Transport Russian logistics items, U.S. and Russian science and technology payloads, and ISS risk mitigation payloads.

ACCOMPLISHMENTS AND PLANS

Russian Space Agency Contract Support

From June 1994 when the Russian Space Agency contract was definitized, through the end of FY 1995, RSA achieved 213 of 313 planned milestones. Major items delivered in FY 1995 include the Shuttle/Mir docking mechanism, hardware for accommodation of

U.S. experiments on Spektr, the integrated implementation plan for science research, the Mir Lifetime Extension Reports (Stage 2 and Stage 3), and ground test equipment for Russia. Also in FY 1995, the Russians launched U.S. experiments on Spektr. Deliverables anticipated in FY 1996 total 175. Major work to be undertaken includes modifications to an active docking mechanism, continued implementation of the integrated science research plan, delivery of qualification and flight hardware for the depress/repress pump assembly, delivery of solar dynamics qualification hardware and ground support equipment, delivery of two passive docking mechanisms, and production of consumable supplies for astronauts. In addition, NASA expects RSA to conduct crew training and crew medical support, and to provide appropriate support for long duration missions.

For FY 1997, milestones to be achieved number 110. Major activities to be conducted include Stage 2 crew training and crew medical support, delivery of ground support equipment, continued implementation of the integrated science plan, delivery of three docking mechanisms, delivery of astronaut consumable supplies, and modification of service module.

Mir Support

In preparation for STS-71 in May 1995, NASA integrated the Russian Flight Article Docking Mechanism to the docking base and structure, tested it, and accepted it early in FY 1995.

In February 1995, the crew of STS-63, including one cosmonaut, performed a rendezvous with and fly-around of the Mir, closing to within thirty-seven feet of the Mir space station. This flight set the stage for STS-71 which was the first of seven docking flights scheduled between mid-FY 1995 and FY 1997.

In March 1995, an American astronaut was launched in a Russian Soyuz capsule to spend three months aboard the Mir. In June 1995, the STS-71 mission docked to the Mir, delivering two new Russian crew members to the Mir, and returning the American astronaut and two Russian cosmonauts. This mission used the docking mechanism which was developed by Russia. During the docked phase of the flight, a number of joint scientific experiments were performed using Mir and Space Shuttle-Spacelab equipment. In addition to transferring crew and conducting scientific experiments, this mission carried logistics necessary for Mir, such as crew clothing, water, and other consumables.

In October 1995, the STS-74 mission delivered a new Russian-built docking module to Mir to allow the Space Shuttle to dock in a more favorable position to the Mir. Two more Space Shuttle missions will be flown to Mir in FY 1996. During FY 1996, American astronauts will spend 6 months aboard the Mir station conducting life sciences and microgravity research. FY 1996 funding for the Spacehab modules will allow continued integration support for the manifested logistics and equipment for delivery to Mir.

Three more Space Shuttle-Mir missions will be performed in FY 1997. Two of these flights will include Spacehab double modules to ferry experiments, logistics and other supplies to the astronauts and cosmonauts. The third flight will also ferry experiments and logistics, on a carrier yet to be determined. As in FY 1996, American astronauts will spend 12 months aboard Mir conducting research in FY 1997, gaining more long-duration space flight experience. Planning will commence for the newly-added eighth and ninth flights to Mir in 1998.

HUMAN SPACE FLIGHT

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE

	FY 1995	FY 1996	FY 1997	Page Number
	(Thousands of Dollars)			
Safety and performance upgrades	710,800	663,400	636.000	HSF 3-4
Shuttle operations	2.444.300	2.485.400	2.514.900	HSF 3-19
To	3.155.100	3.148.800	3.150.900	
Distribution of Program Amount by Installation				
Johnson Space Center	869,500	953.600	879.800	
Kennedy Space Center.	835.000	812.900	799.700	
Marshall Space Flight Center	1.351.600	1,302,500	1,387,800	
Stennis Space Center	49,400	45,400	50.900	
Dryden Flight Research Center	6,100	5.600	5.400	
Goddard Space Flight Center	--	--	--	
Jet Propulsion Laboratory	--	200	--	
Headquarters..	43.500	28.600	27.300	
To	3.155.100	3.148.800	3.150.900	

GENERAL

The Space Shuttle budget is divided into two categories: Safety and Performance Upgrades (S&PU) and Shuttle Operations. It is distributed to the various program elements through the four Office of Space Flight Centers and the Dryden Flight Research Center.

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 countries and international agencies. Examples of international participation which the Space Shuttle is uniquely suited to support include:

- the retrieval of the Japanese space flyer unit in early 1996
- 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 access to the space environment. Over 50 payloads with numerous experiments have been developed through these consortia and are scheduled for flight in FY 1996.

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 FY 1998, a major cooperative NASA-NIH program, is a prime example.

As background, since FY 1992, extensive restructuring of the program has yielded a 24% budget reduction through FY 1995 (over 30% in FY 1992 dollars). This was accomplished principally through reductions in flight rate, program content, contract consolidation and restructuring, and the accomplishment of continuous improvement efficiencies. During FY 1995, the program was challenged with additional budget reductions for FY 1997 through FY 2000. At the same time, a strategic shift within the Agency dictated that civil servants should be reduced in operational activities so the Agency could concentrate its human resources on research and development. The program met this challenge by conducting an extensive internal program review which entailed a review of design and flight requirements and roles and missions given the Shuttle's mature operational state. The result of that review was a commitment to downsize and restructure the program.

In the past year, an independent Functional Workforce Review (FWR) was conducted to: 1) look for any safety deficiencies in the program resulting from the previous three years of downsizing: 2) verify every task, function. organization. and worker, both government and contractor, required to safely fly seven flights per year and 3) recommend any improvements. additions. or cuts as appropriate. This review concluded that: 1) currently. there are no safety "holes" in the program: 2) there are several areas where previous cuts have resulted in a lack of schedule flexibility: and 3) there are still reductions to be made in tasks, functional overlaps, and program requirements which will allow further reductions in the workforce through FY 1997. These additional reductions are reflected in our budget planning. Although most of the reductions will be made by the end of FY 1997. these cuts

will have the long-term benefit of meeting out-year budgets as they allow us to do the job with fewer people than previous planning anticipated. Other restructuring initiatives were required, however, to fully respond to the challenge.

Another major study. the results of which were published in the 'Report of the Space Shuttle Management Independent Review Team" (KraftReport). was completed in March 1995. This report made a number of recommendations directed at Space Shuttle management, most of which were already in various stages of implementation. The remaining recommendation. consolidation into a single prime contractual arrangement, was deemed consistent with Agency goals, and was accepted in August 1995 when NASA management announced the further consolidation of Shuttle contracts into one Space Flight Operations Contract (SFOC). Further discussion of SFOC can be found under the Shuttle Operations budget discussion.

PROGRAM *GOALS*

The program goals of the Space Shuttle program. in priority order are: 1) fly safely: 2) meet the flight manifest: and, 3) reduce costs. These goals are reflected in our decisions regarding flight requirements, budget reductions and programmatic changes. The flight rate for FY 1997 and beyond is seven to eight flights per year, and supports the nation's science and technology objectives through scheduled Spacelab and other science missions, cooperative missions to the Russian space station Mir, and assembly of the International Space Station.

STRATEGY FOR ACHIEVING GOALS

The budget structure of the Space Shuttle program consists of two major components: Safety and Performance Upgrades and Space Shuttle Operations. 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. Shuttle Operations including hardware production, ground processing. launch and landing, mission operations, flight crew operations, training, logistics, and sustaining engineering. In addition, this budget includes funding for facilities related to the Space Shuttle.

The Space Shuttle program's strategy for the Safety and Performance Upgrades budget is to complete current Safety and Performance improvement projects. and then freeze the Shuttle design except for any upgrades required due to safety, obsolescence, or environmental requirements.

The overall strategy for the Shuttle Operations budget is to request funding levels sufficient to meet the Intended flight rates, including appropriate contingency planning in both budget and scheduled allowances to assure transportation and assembly support to the Space Station program, while at the same time seeking opportunities to eliminate marginal value-added activities which enables reductions in operations costs. The SFOC represents a key element of this strategy.

BASIS OF FY 1997 FUNDING REQUIREMENT

SAFETY AND PERFORMANCE UPGRADES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Orbiter improvements	194.800	258.700	169.900
Orbiter improvements	194.800	258.700	169.900
(Multifunction electronic display system)	(37,900)	(40.600)	(40,600)
(Simplified aid for EVA rescue)	(2,800)	(6,600)	(7,900)
(Global positioning system)	(2,000)	(2,100)	(500)
(Other orbiter improvements)	(152,100)	(209,400)	(120.900)
Propulsion upgrades	399.200	296.800	342.800
Space shuttle main engine upgrades	318.900	251,300	309,500
(Alternate turbopump program)	(82.300)	(119.000)	(144,600)
(Other main engine upgrades)	(236.600	(132,300)	(164,900)
Solid rocket booster improvements	39.100	1,400	2.100
Super lightweight tank	41.200	44,100	31.200
Flight operations & launch site equipment upgrades	104.500	90.500	115.000
Flight operations upgrades	54,300	69.400	69,500
Launch site equipment upgrades	50.200	21. 100	45.500
Construction of facilities	12.300	17.400	8.300
Replace component refurbishment facility	(7,500)		
Modernize fire system. pads A and B	(4,800)	(5,000)	
Replace space shuttle main engine processing facility		(4,900)	
Replace chemical analysis facility		(7,500)	
KSC pad B fixed service structure/elevator			(1,500)
KSC pad B chiller			(1,800)
SSC high pressure water system refurbishment			(2,500)
MSFC michoud assembly facility electric distribution			(2,500)
Total	710.800	663.400	636.000

GENERAL

In the past year, significant changes to the Safety and Performance Upgrades (S&PU) plan included: termination of the Reusable Solid Rocket Motor (RSRM) Nozzle effort at Iuka, Mississippi: deletion of the extended nozzle and lightweight Solid Rocket Booster efforts (both were performance enhancements no longer required for Space Station assembly): and cancellation of reaction control system direct acting valve and engine health monitoring (except for thermocouples). All these activities were part of the FY 1996 S&PU program. There have been no new initiatives. Work continues on major developments such as the Alternate Turbopump Development (ATD), Large Throat Main Combustion Chamber (LTMCC), and the Multifunction Electronic Display System (MEDS).

The FY 1997 budget includes activities in the following categories: Orbiter Improvements, Space Shuttle Main Engine (SSME) Upgrades. Super Lightweight Tank (SLWT) development, Launch Site Equipment (LSE) Upgrades and Flight Operations Upgrades. as well as specific, Space Shuttle-related Construction of Facilities. The following is a brief description of these activities.

Orbiter Improvements

The Orbiter improvements program provides for enhancements of the Space Shuttle systems, produces space components that are not susceptible to damage. and maintains core skills and capabilities required to modify and maintain the Orbiter as a safe and effective transportation and science platform. These activities are provided by contract arrangements with the Rockwell International Space Division in two major locations in FY 1997: the Downey, California facility provides engineering. manufacturing and testing: and the Houston, Texas operation provides engineering and problem resolution. Other activities that support this effort are subsystem management engineering and analysis conducted by Lockheed-Martin Corporation. and development and modifications required for support to the extravehicular capability conducted by Hamilton Standard.

Orbiter Maintenance Down Period (OMDP) occurs when each Orbiter is taken out of service periodically for detailed structural inspections and thorough testing of its systems before returning to operational status. This period also provides opportunities for major modifications and upgrades, especially those upgrades that are necessary for improving performance to meet the International Space Station operational profile.

Propulsion Upgrades

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 main engine components 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 that 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 activities are accomplished at the KSC engine shop.

Engine ground test and flight data evaluation, hardware anomaly reviews and anomaly resolution are managed by the MSFC. The Alternate Turbopump project is also managed by the MSFC under contract with Pratt Whitney of West Palm Beach, FL. Development of the SLWT is managed by the MSFC and is being accomplished by the Lockheed-Martin Corporation at the government-owned Michoud Assembly Facility (MAF) near New Orleans, LA.

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). 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 ensure their readiness to launch the Space Shuttle. Most of the planned upgrades in the near-term are at KSC.

PROGRAM GOALS

NASA planning assumes continued utilization of the Space Shuttle through the year 2012. which is the planned life span of the International Space Station. In order to maintain a viable. human transportation capability that will operate into the next century and support NASA's launch requirements, specific program investments are required. These investments will be consistent with NASA's strategy of freezing the design while we await a decision in the year 2000 concerning the future space transportation capability beyond 2012.

STRATEGY FOR ACHIEVING GOALS

This budget provides funds required to modify and improve the capability of the Space Shuttle to ensure its viability as a safe, effective transportation system and scientific platform. It also addresses increasingly stringent environmental requirements, obsolescence of subsystems in the flight vehicle and on the ground, and reduction in operational costs. Work continues on the Alternate Fuel Turbopump and new Large Throat Main Combustion Chamber (LTMCC) for the planned introduction of the block 11 Space Shuttle Main Engine (SSME) in late FY 1997.

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 1997 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 in order to meet our manifest requirements.

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 1997. the program continues to develop the Super Light Weight Tank which will provide 7500 pounds of weight savings toward the 13,000 overall performance improvement needed to support the first Space Station launch in December 1997. Development will also continue to replace the Orbiters' cockpit displays with MEDS. replacing Tactical Air Command and Navigation System (TACAN) with Global Positioning System (GPS), upgrading the T-38 aircraft with maintainable systems, replacing elements of the launch site complex, upgrading major elements of the training facilities at JSC. testing of main engine components at Stennis Space Center, testing of Orbiter reaction control 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 ensure compatibility of the shuttle vehicles with the new Space Station operational environment. Orbiter weight reductions have been identifled 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 International 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.

During FY 1995. Columbia (OV-102) completed its OMDP and reentered the fleet in time to fly STS-73 in October 1995. Discovery (OV-103) followed Columbia and is currently undergoing maintenance structural inspections and modifications required for docking with the International Space Station at the Palmdale. California, facility and is expected to be complete in June 1996. In FY 1997. Endeavor (OV-105) will enter OMDP for normal maintenance, structural inspections. and will also be modified for docking with the International Space Station.

The Multifunction 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 directly benefiting 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. 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. The first flight of a MEDS equipped Orbiter is planned for FY 1999.

Expansion of the effort to replace the Orbiter's TACAN landing navigation system with the Global Positioning System (GPS) began 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 FY 1999.

In addition to modifying the Orbiter itself for Space Station operations, production of SAFER (Simplified Aid for Extravehicular Rescue) began 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. Five SAFER flight units will be produced and fabricated along with two ground tests 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 to be performed on a Space Shuttle-Mir docking flight STS-76/Mir-03 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 flow will be conducted to ensure safety and reliability is 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 once the bearings were tested, accepted and introduced into the ATD HPOTO. Testing proceeded successfully with completion of certification testing and first flight was accomplished in FY 1995. The high pressure fuel turbopump, restarted during FY 1995, is scheduled to support completion in FY 1997.

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 producibility 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 main objective of the large throat main combustion chamber (LTMCC) development is to lower chamber pressure. resulting in lower pressures and temperatures throughout the engine system thereby increasing the overall Shuttle system flight safety and reliability. The wider throat area 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 producibility of the chamber. The powerhead. heat exchanger and LTMCC are all being performed under contract with the Rocketdyne Division of Rockwell International Corporation.

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 was introduced and flown for the first time in July 1995. The Block II is scheduled to be flown in FY 1997 and consists of the large throat main combustion chamber 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 producibility. 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 new sensors (temperature pressure and flow) for use in the SSME. 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 an in-flight abort. 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 1996.

In FY 1995. both a Preliminary Design Review (PDR) and a Critical Design Review (CDR) were completed for the Super Lightweight External Tank leading to the release of drawings to the manufacturing process at the Michoud Assembly Facility. During FY 1996, the Aluminum Lithium Test Article (ALTA) will complete its structural and proof testing to certify the design for the use on the Space Shuttle, with its initial flight planned for late FY 1997.

Flight Operations and Launch Site Equipment Upgrades

These upgrades support pre-launch and post-launch processing of the four Orbiter fleet. Key enhancements funded in launch site equipment include: replacement hydraulic pumping units that provide power to Orbiter flight systems during ground processing; replacement of 16-year old ground cooling units that support all Orbiter power-on testing; replacement communications and tracking Ku-band radar test set for the labs in the Orbiter Processing Facility and High Bays that supports rendezvous capability and the missions: communications and instrumentation equipment survivability projects that cover the digital operational intercom system, major portions of KSC's 17-year old radio system, and the operational television system: improvement of the Shuttle operations data network that supports interconnectivity between Shuttle facilities and other KSC and off-site networks; replacement storage tanks and vessels for the propellants, pressurants, and gases: an improved hazardous gas detection system: and fiber optic cabling and upgrades.

The new MCC, completed in FY 1995 and supporting mission operations for all flights thereafter. has 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 are reduced due to fewer computer breakdowns.

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

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system reliability and maintainability. Design reviews have been completed and procurement was initiated in FY 1993, Production and installation should be complete in FY 1999.

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. The upgrade should be complete in late FY 1998.

With the termination of the Launch Processing System Control. Checkout and Monitoring System Upgrade (CCMS-XI), the CCMS survivability project supports extension of the CCMS for the life of the Space Shuttle program. This project recycles existing CCMS racks, console enclosures and selected cables, modifies CCMS facilities in the Launch Control Center and provides the engineering and transition to drop-in subsystem replacements that replicate the existing CCMS. The Central Data Subsystem equipment survivability project ensures continued reliable operation for the duration of the Space Shuttle program, including migration to an open system platform mandated by Federal information data system standards.

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 and 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 ensure 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 5-minute window required for operations with the Space Station. Design reviews for the DOIJLU-11 were completed in FY 1995 and the first mission using this system was *STS-70* in July 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 (CofF)

FY 1995 CofF funding was concentrated on the KSC facilities. The 25 year old fire extinguisher piping (much of it underground) was replaced. Also, the 25 year old facility at KSC used for components refurbishment began a major renovation. 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 CofF 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.

FY 1997 CofF funding is concentrated on facilities at KSC, MAF, and SSC. At KSC, there are two projects at Launch Complex Pad B. They are for the replacement of Pad B chiller system and the restoration of the Fixed Support Structure Elevator System. Both systems are over 25 years old and are past their economic life expectancy. These systems are part of a critical path for launch criteria assurance. At MAF, the rehabilitation and modification of the 48-volt electrical system are necessary to protect critical manufacturing operations in the final assembly and major weld areas for the manufacturing of the ET. At SSC, the restoration of the High Pressure Industrial Water Plant will include the overhaul of three diesel engines for the deluge water system and two diesel engines for the electrical generation system. These engines drive the water pumps and electrical generators that provide cooling water and reliable power for all three SSME test stands for flight certification and development testing.

MEASURES OF PERFORMANCE

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the ongoing projects consistent with approved schedule and cost planning. Success depends on developing these projects and getting them implemented to help ensure 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 ensures that new projects are evaluated, approved and initiated on a priority basis, and that existing projects meet established cost and schedule goals. Significant milestones are listed below:

Orbiter Improvements

Simplified 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 International Space Station.

Initial SAFER Flight Plan: 4th Qtr FY 1996 Revised: 2nd Qtr FY 1996	Demonstrated on Mir-04 flight. The unit will now be utilized for the first time on the STS-76/Mir-03 flight.
Conduct Preliminary Design Review (PDR) for SAFER Plan: 2nd Qtr FY 1996 Revised: 3rd Qtr FY 1996	Completion of PDR will allow design of the production units to proceed toward CDR
Conduct Critical Design Review (CDR) for SAFER 4th Qtr FY 1996	Completion of CDR will allow production to proceed so that SAFER will be available for joint Space Shuttle-Mir Joint spacewalk on STS-86/Mir-07 Flight in FY 1996. [Note: correction made here from FY 1996 budget plan for typographical error]

Multifunction 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 Plan 1st Qtr FY 1996 Revised 3rd Qtr FY 1996	Complete hardware qualification testing and start hardware integration and verification testing. The qualification program was extended through this date. No significant impact to initial operating capability is expected.
MEDS Initial Operational Capability (IOC) Plan: 4th Qtr FY 1998 Revised: 1st Qtr FY 1999	First flight of a MEDS equipped Orbiter.

Global Positioning System (GPS) - GPS will replace TACAN in the Orbiter navigation system when the military TACAN ground stations will be phased out in the year 2000. The planned readiness date for the Space Shuffle's system is FY 1999.

Complete GPS Preliminary Design Review (PDR) 4h Qtr FY 1996	Completion of PDR will allow design drawings to proceed toward CDR
Complete GPS Critical Design Review (CDR) 4th Qtr FY 1997	Completion of CDR will allow drawings to be released for production to proceed.

Complete GPS operational capability - FY 1999	Initial operation of GPS without TACAN system.

Orbital Maintenance Down Periods

Complete Columbia (OV-102) OMDP Plan: 4th Qtr FY 1995 Actual: 3rd Qtr FY 1995	Routine Maintenance period for Columbia.
Complete Discovery (OV-103) OMDP - Plan: 1st Qtr FY 1997 Revised: 3rd Qtr FY 1996	Conduct routine maintenance: outfit Discovery with external airlock; fifth cryogenic tank; preparations for Shuttle rendezvous with Mir and the International Space Station. Rephased/advanced schedule to meet manifest requirements
Initiate Endeavour (OV-105) OMDP - 4th Qtr FY 1996	Conduct routine maintenance; prepare Endeavour for the International Space Station operations; outfit with external airlock

Propulsion Upgrades

Super Lightweight Tank - This performance enhancement is designed to provide 7,500 pounds of additional performance for the Space Shuttle to allow rendezvous and operations with the International Space Station.

Critical Design Review (CDR) of Super Lightweight Tank Plan: 3rd Qtr FY 1995 Actual: 3rd Qtr FY 1995	The Super Lightweight Tank will provide 7.500 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.
Design Certification Review 2nd Qtr FY 1997	The Super Lightweight Tank will provide 7,500 pounds of performance through incorporation of an aluminum-lithium alloy in the external tank structure.
Deliver first SLWT to KSC for flight Plan: 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 Plan: 3rd Qtr FY 1996 Actual: Canceled	The lightweight booster will provide 1,200 pounds of performance enhancements through redesign of the decelerator (parachute system). Project was canceled during FY 1995 because additional weight reductions were identified that were more cost-effective.
Deliver first Lightweight Booster to KSC for flight plan: 1st Qtr FY 1997 Actual: Canceled	Project was canceled during FY 1995 because additional weight reductions were identified that were more cost-effective.
Conduct Qualification Tests on RSRM Nozzle Cone Extension plan: 4th Qtr FY 1997 Actual: Canceled	Extending the RSRM Nozzle cone combined with increasing the diameter will increase the specific impulse and provide a payload gain of 500 pounds. Project was canceled during FY 1995 because additional weight reductions were identified that were more cost-effective.
Delivery of initial RSRM production nozzle Plan: April 1998 Actual: Canceled	Project was canceled during FY 1995 because additional weight reductions were identified that were more cost-effective.

Space Shuttle Main Engine Safety Improvements - Introduction of Block I and Block 11 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 Plan: 3rd Qtr FY 1995 Actual: 4th Qtr FY 1995	The High Pressure Oxidizer Turbopump was combined with single-coil heat exchanger and the phase 11+ Powerhead. First flight was STS-71 in July 1995.
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 11 Engine upgrade.
First flight of the Block 11 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 - Upgrades to the Mission Control Center will occur during FY 1995-97 period improving operations reliability and maintainability and also taking advantage of the state-of-the-art technology in displays and controls. In addition. upgrades to the Launch Site Equipment at KSC will increase reliability and reduce obsolescence.

Begin on-orbit simulations from new MCC Plan: 2nd Qtr FY 1995 Actual: 4th Qtr FY 1995	Conduct a series of simulations to test new hardware/software in the MCC.
Begin on-orbit mission operations from new MCC Plan: 2nd Qtr FY 1995 Actual: 4th Qtr FY 1995	Conduct on-orbit simulations before ascent/entry to ensure system reliability.
Begin ascent/entry mission support from new MCC Plan: STS-73 - 1st Qtr FY 1996 Revised: STS-75 - 2nd Qtr FY 1996	Complete entire mission profile with the new MCC.
Replacement of displays and controls 3rd Qtr FY 1996	Installation of new state-of-the-art system will allow more efficient operations.
New MCC front end implementation and decommissioning of associated obsolete equipment and consoles 4th Qtr FY 1996	Implementation of new commercial off-the-shelf (COTS) system will allow removal of obsolete custom built equipment with significant reduction in life cycle costs.
Implementation of new MCC command server system 4th Qtr FY 1996	Removal of command functions from the mainframe Mission Operations Computer (MOC) is a major step towards deletion of the MOC in FY 1997 which will significantly reduce command and control life cycle costs.

Complete development of the new Consolidated Planning System (CPS) and initiate phase- out of existing obsolete Shuttle Flight Planning System (FPS) 4th Qtr FY 1996	Implementation of the new commercial off-the-shelf (COTS) hardware/software based planning system will enable phase-out of existing higher life cycle cost FPS and enable common planning tool for Shuttle and Station operations.

Launch Site Equipment Upgrades

Complete validation of Hardware Interface Modules (HIM Cards) Plan: 3rd Qtr FY 1995 Actual: 3rd Qtr FY 1995	First production unit delivered and tested by user.
Deliver first two Portable Purge Units 4th Qtr FY 1996	First units delivered and tested by user.

Construction of Facilities

Restore Fire Extinguisher Pumps and Piping at LC-39 Plan: FY 1995 Revised: FY 1996	Restoration is needed. Pumps are currently inadequate to provide spray coverage during an emergency.

Replace Component Refurbishment and Chemical Analysis Facility at KSC FY 1997	Facility is 25 years old, in non-compliance with OSHA standards, overcrowded and insulated with asbestos. Completing this effort in FY 1997 is earliest opportunity to comply with CFC requirements during cleaning and degreasing operations.
Phase I Plan - 2nd Qtr FY 1995 Actual - 1st Qtr FY 1997	Complete activation of component refurbishment building. Delay due to extended negotiation with the activation contractor.
Phase 11 Plan - 2nd Qtr FY 1995 Revised - FY 1996	Begin construction of chemical analysis facility. Construction will begin approx. 90 days following approval of the FY 1996 appropriation bill.
Phase 11 Plan - FY 1998	Complete activation of chemical analysis facility. Completion is scheduled for 21 months following construction initiation.

BASIS OF FY 1997 FUNDING REQUIREMENT

SHUTTLE OPERATIONS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Orbiter and integration	528,200	521,000	516,600
(Orbiter)	(358,700)	(378.500)	(375,400)
(System integration)	(169,500)	(142.500)	(141,200)
Propulsion	1,007,000	1,061,500	1,098,700
(External tank)	(305,000)	(327,500)	(348,700)
(Space shuffle main engine)	(168,300)	(185,000)	(172,300)
(Reusable solid rocket motor)	(370,700)	(395,700)	(402,900)
(Solid rocket booster)	(163,000)	(153,300)	(174,800)
Mission and launch operations	909,100	902,900	899,600
(Launch and landing operatlons)	(621,400)	(544,000)	(609,900)
(Mission and crew operations)	(287,700)	(358,900)	(289,700)
To	2,444,300	2,485,400	2,514,900

GENERAL

Space 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 1996 planned standard service reimbursements total $15.7 million, with $23.5 million assumed in FY 1997. These reimbursements have *already* been assumed in the budget request.

The Space Shuttle operatlons budget includes sustaining engineering, hardware and software production, logistics, night and ground operations, and night crew operations for all elements.

Orbiter and Integration

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

(1) Orbiter logistics: spares for the replenishment of line replacement units (LRUs) and shop replacement units (SRUs) *along* with the workforce required to support the 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 extravehicular activity:
(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 included in this budget element.

The major contractors for these Orbiter activities are Rockwell International for logistics, external tank disconnects and Orbiter sustaining engineering, and Hamilton Standard and Boeing for flight crew equipment processing.

System integration includes those elements managed by the Space Shuttle Program Office at the Johnson Space Center (JSC), 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 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 multiprogram support at the JSC. Rockwell International, Space Division. is the major contractor for this function.

Propulsion

External tanks are produced by Lockheed-Martin 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 Management Command (DCMC) support in the quality assurance and inspection of Space Shuttle hardware: and funds for transportation and logistics costs in support of SSME flight operations. Rocketdyne, a division of Rockwell International Corporation, provides the bulk of the engine components for flight as well as sustaining engineering, Integration. and processing of the SSME for flight.

The Solid Rocket Booster (SRB) project 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 Reusable Solid Rocket Motor (RSRM) project 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 (primary), DFRC (back-up) and contingency sites.

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 provides 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, and
(7) Preparation and plans for International Space Station assembly.

Also included are the Mission Control Center (MCC), Integrated Training Facility (ITF), Integrated Planning System (IPS), and the Software Production Facility (SPF). With the exception of the SPF (Shuttle only), these facilities integrate the mission operations requirements for both the Space Shuttle and International 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 are 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.

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 to eight flights per year from FY 1997 through FY 2001.

STRATEGY FOR ACHIEVING GOALS

The Space Shuttle program is aggressively continuing to 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.

A non-competitive Request for Proposal was issued to the United Space Alliance (USA) in January 1996. It includes a three-phase approach to a single prime contract for Shuttle operational activities. The first phase would begin in late FY 1996 with contract award. The scope of phase I is envisioned to incorporate the majority of the effort currently conducted by Lockheed-Martin and Rockwell International (the two companies which comprise the USA joint venture) to be relegated to the prime contract. The second phase will add other operations work to the contract after the contractor has had an appropriate amount of time to evolve into its more responsible role in phase I. The third phase will be completed in FY 2000. By that time, all operations will be under the prime contractor. The reasons for this phased approach are two-fold:

1. The ongoing major development projects (e.g. SLWT, MEDS, ATD, etc.) will be completed.
2. The transition to the prime can occur at a more measured pace.

ACCOMPLISHMENTS AND PLANS

In FY 1995. the Space Shuttle launched six flights successfully including first flight to dock with the Russian Mir in June 1995 at high inclination orbit to support design and assembly of the International Space Station. In addition, the full capability of an extended duration flight demonstrated a 17-day mission with the ASTRO-2 payload. Other major payloads flown in FY 1995 include:

- exploration and measurement of atmospheric variability for the U.S. and Germany
- a mission with the Space Radar Laboratory and Tracking and Data Relay Satellite
- two separate missions with the Shuttle Pointed Autonomous Research Tool for Astronomy
- experiments involving molecular and chemical growth of compound semi-conductors in the Wake Shield Facility
- measurement of atmospheric parameters from a platform using laser sensors and verifications of space-born Lidar Systems
- measurement of long-term variability in energy radiated by the sun and determination of variability in the solar spectrum
- materials processing mission emphasizing research in microgravity conditions, and
- over 42 middeck payloads

At the same time, the program continued to reduce the size of the workforce based on recommendations from the Functional Workforce Review teams, as well as other on-going reviews and continuous improvement initiatives.

The eight-flight manifest for FY 1996 includes a combined reflight of the Tethered Satellite and microgravity materials processing mission: the fourth flight of the commercial Spacehab Module and SPARTAN inflatable antenna experiment: retrieval of two free-flyer satellites (one launched by the Japanese (SFU) and one launched by NASA) and Spacehab missions; and life and microgravity science mission. Also, the second, third. and fourth in a series of missions between the U.S. Space Shuttle and the Russian Space Station Mir are planned in FY 1996. The primary purpose of the second mission in November 1995 was the installation of a docking module that will improve clearance between the Space Shuttle and the Mir solar arrays during docking.

By the end of FY 1996. it is expected that a contract will be signed with the Space Shuttle single prime contractor. This will begin phase I of the operations consolidation wherein the major ground and flight operations work done today by Lockheed Martin and Rockwell International will be consolidated into a single program contract. This will initiate an approximately two-year transition of civil service from their current roles in project management and oversight to providing, on behalf of the Space Shuttle Program Manager. insight into the prime contractor's activities through audits, surveillance. assurance, and independent assessments of any problems or anomalies which are unique or have not been previously addressed (i.e. 'out-of-family").

FY 1997 will see three more docking missions to the Mir carrying station and experiment logistics, and providing crew exchange. The Space Shuttle will also carry and deploy the Wake Shield Facility for a third time and make a second servicing visit to the Hubble Space Telescope - replacing 2 current science instruments with 'second generation" instruments, and refurbishing some telescope support systems. The Japanese Manipulator Flight Demonstration mission will provide some prototype testing for robotics systems to be part of the Japanese Experiment Module on the International Space Station. The Microgravity Science Laboratory mission (MSL) will study protein crystal growth, combustion. and material science furnace experiments.

MEASURES OF PERFORMANCE

Since the Space Shuttle program has both an operational and development component, performance measures related to the Space Shuttle program reflect a number of different activities ranging from missions planned and time in-orbit in Shuttle operations. to development milestones planned for the Safety and Performance Upgrades program. The following sets of diverse metrics can be utilized to assess overall program performance.

Space Shuttle Missions and Primary Payloads

FY 1995		Plan	Actual
STS-66/Atlantis	Atmospheric Laboratory for Applications and Science (ATLAS-3)	October 1994	November 1994
STS-63/Discovery	Spacehab-3	February 1995	February 1995
STS-67/Endeavour	Astronomy (ASTRO-2)	March 1995	March 1995
STS-71/Atlantis	Russian Space Station Mir (Mir-1)	May 1995	June 1995
STS-70/Discovery	TDRS-G Satellite Deployment	June 1995	July 1995
STS-69/Endeavour	Wake Shield Facility-2 (WSF-2)/Spartan 201-03	July 1995	September 1995

FY 1996		Plan/Revised	Actual
73/Columbia	United States Microgravity Laboratory (USML-2)	September 1995	October 1995
STS-74/Atlantis	Russian Space Station Mir (Mir-2)	October 1995	November 1995
STS-72/Endeavour	SFU Retrieval/OAST-Flyer Deployment	November 1995	January 1996
STS-75/Columbia	Tether Satellite System Reflight (TSS-1R)/USMP-3	February 1996	February 1996
STS-76/Atlantis	Russian Space Station Mir (Mir-3)	March 1996	
STS-77/Endeavour	Spacehab-4	April 1996/May 1996	

STS-78/Columbia	Life/Microgravity Sciences (LMS-1)	June 1996
STS-79/Atlantis	Russian Space Station Mir (Mir-4)	August 1996

FY 1997		Plan/Revised
STS-80/Columbia	Wake Shield Facility-3 (WSF-3)/OREFUS-SPAS-02	November 1996
STS-8 1/Atlantis	Russian Space Station Mir **(Mir-5)/Spacehab**	December 1996
STS-82/Discovery	Hubble Space Telescope Servicing Mission (MSTSM-02)	February 1997
STS-83/Columbia	Microgravity Science Laboratory (MSL- 1)	April 1997/March 1997
STS-84/Atlantis	Russian Space Station Mir (Mir-6)/Spacehab	May 1997
STS-85/Discovery	Japan Manipulator Flight Demonstration/CRISTA-SPAS-02	July 1997
STS-86/Atlantis	Space Station Mir (Mir-7)	September 1997

	FY 1995		FY 1996		FY 1997
Operations Metrics	Plan	Actual	Plan	Current	Plan
Number of Space Shuttle Flights*	7	6	7	***8***	7
Shuttle Operations Workforce (prime Contractors)**	16.594	17,807	15,701	16,707	15.961
Number of Days On-orbit	74	66	74	90	80
Number of ***primary*** Payloads **Flown**	9	9	**9**	12	9

- Technical and weather-related problems caused the USML-2 launch to slip from FY 1995 to FY 1996.

** The contractor workforce data have been modified to include indirect **as** well **as** direct contractor workyears, which accounts for the variances in actuals and plans.

Shuttle processing time has been cut in half, from 1.6 million hours per mission in FY 1989 to 800,000 hours per mission in FY 1994, and the cost per Shuttle flight has been reduced in the last two years **by** $43 million. Yet the system **is** operating **with** greater effectiveness **than** ever, while maintaining quality and safety standards of the highest order. The late summer stand **down** of Shuttle launches **is** an example of the safety system's success in identifying and rectifying potential problems before they have the opportunity to cause serious harm. During FY 1995. **six** missions were **flown** with 35 crew members for approximately **400** crew days, or 512 crew days if the time spent **by** an American astronaut aboard Mir **is** included. For FY 1996, NASA plans to ***fly 8*** missions with 772 crew days on orbit. including 194 crew days **aboard** Mir.

NASA continues to seek ways to monitor the overall performance of the Space Shuttle program. In order to permit rapid review **by** the **Program** Director, the Shuttle program has devised a series of "stoplight" metrics, whereby certain program aspects *are* measured against established limits or program parameters and then translated into the appropriate green, yellow or red indicators. Among the metrics displayed in this manner **are** in-flight anomalies, monthly cost rate. KSC monthly mishaps. Orbiter

systems and line replaceable unit (LRU) problem reports, Shuttle processing contract overtime percentage, and KSC quality surveillance error rate. The Shuttle program also tracks its launch history, monitoring the number of lift-off attempts per mission, and characterizing any delays or scrubs as to technical, weather or operational-related reasons.

Payload and
Utilization Operations

HUMAN SPACE FLIGHT

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

PAYLOAD AND UTILIZATION OPERATIONS

	FY 1995	FY 1996	FY 1997	Page Number
		(Thousands of Dollars)		
Spacelab	90,900	86,700	62,400	HSF 4-3
Tethered satellite system	7.400	3,800	--	HSF 4-7
Payload processing and support	44,000	40.600	42,700	HSF 4-9
Advanced projects	12.200	12.200	15.200	HSF 4-12
Engineering and technical base	165.600	171.700	151.500	HSF 4-17
To	320.100	315.000	271.800	
Distribution of Program Amount by Installation				
Johnson Space Center	77,000	81,100	68,000	
Kennedy Space Center	98,200	87,100	81,300	
Marshall Space Flight Center	127,200	115.700	100,700	
Stennis Space Center	1,800	1,600	1,700	
Langley Research Center	--	300	200	
Lewis Research Center	300	--	--	
Goddard Space Flight Center	11,900	7,900	7,300	
Headquarters	3.700	21.300	12.600	
To	320.100	315.000	271.800	

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 1997 strategy includes plans to further reduce the workforce while maintaining or continuing to improve customer satisfaction.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACELAB

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Spacelab	90,900	86.700	62.400

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 cofiguration. 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, 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.

Spacelab operations support is comprised of 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 two 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 such as 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 performed 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 123 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 and data can be received using the aft flight deck computer/standard switch panels or from the ground through the payload operations control center (POCC).

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 is used on the Hubble Space Telescope (HST) repair/revisit missions.

A major operational cost reduction program has been underway over the past year, with the goal of reducing the Spacelab budget by 3%. That reduction has been achieved for FY 1995. 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 also supported by a contract with McDonnell-Douglas.

The last Spacelab flight is scheduled for early 1998. with the advent of the more permanent science laboratory flown by the International Space Station.

MEASURES OF PERFORMANCE

Spacelab Missions	plan	Actual
Atmospheric Laboratory for Application and Science (ATLAS-3)	October 1994	November 1994
Astronomy (ASTRO-2)	March 1995	March 1995
Space Station Mir (Mir-1)	May 1995	June 1995
United States Microgravity Laboratory (USML-2)	September 1995	October 1995
Tether Satellite System Reflight (TSS-1R)	February 1996	February 1996
United States Microgravity Payload (USMP-3)	February 1996	February 1996
Life/Microgravity Sciences (LMS-1)	June 1996	
Microgravity Science Laboratory (MSL-1)	March 1997	
United States Microgravity Payload (USMP-4)	October 1997	
Space Life Sciences Laboratory-4 (Neurolab)	March 1998	

	FY 1995		FY 1996		FY 1997
Flight Hardware Utilized	Plan	Actual	plan	Current	Plan
Long Module	1	2	1	2	1
Multi-Purpose Experiment Support Structures (MPESS)			1	1	
Pallets	2	2			
Pallets Plus MPESS			2	1	
Hitchhiker Experiments	10	10	TBD	9	11
Get Away Special Payloads	7	6	TBD	15	TBD
Contractor Workforce					
KSC (McDonnell-Douglas)	369	369	254		253
MSFC (McDonnell-Douglas)	262	262	192		160

ACCOMPLISHMENTS AND PLANS

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

In FY 1996, the Spacelab program will fly the following manifested missions: United States Microgravity Laboratory (USML-2) module mission, the Tether Satellite System Reflight (TSS-1R), United States Microgravity Payload (USMP-3).the Life and Microgravity Sciences (LMS) module mission, fifteen GAS payloads and nine Hitchhiker experiments.

Regarding FY 1997 activities. the Spacelab program will integrate and process Spacelab missions consistent with the Shuttle manifest including the Microgravity Sciences Laboratory (MSL-1) mission, as well as 11 Hitchhiker payloads and several GAS payloads. Worts will be increased during the fiscal year to prepare for the Spacelab program phase-down (excluding the Hitchhiker, GAS and FSS programs)) hardware/software disposition, final program flight and closing of the Operations and Checkout facility presently projected for late FY 1998.

BASIS OF FY 1997 FUNDING REQUIREMENT

TETHERED ATELLITE SYSTEM

	FY 1995	FY 1996	FY 1997
		[Thousands of Dollars)	
Tethered satellite system reflight	7.400	3,800	--

PROGRAM GOALS

The goal of the Tethered satellite system reflight (TSS-1R) program is to study the electro-dynamics 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 identifled 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, 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 Marshall 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

	plan	Actual
Delivered science instruments to KSC	February 1995	February 1995
Completed Level IV experiment integration	March 1995	March 1995
Satellite turnover from ASI/ALENIA to NASA	April 1995	April 1995
Began simulation training	August 1995	September 1995
Independent assessment of mission readiness	1st Qtr 1996	4th Qtr 1995
Launch TSS-1R	February 1996	February 1996
De-integrate TSS-1R	April 1996	
Post Mission Report	May 1996	

ACCOMPLISHMENTS AND PLANS

In FY 1995, NASA completed final verification of the satellite and science instruments and mission peculiar modifications to the payload operations control center. The hardware was shipped to Kennedy Space Center where final assembly of the payload was accomplished and interfaces verified. Simulation training was initiated and Shuttle interface documents and flight procedures were baselined.

In FY 1996. the TSS-1R program completed integrated mission simulations, conducted an end-to-end communications test of the flight operations configuration, installed the payload in the Shuttle, and held flight readiness reviews. The TSS-1R mission was launched on STS-75 in February 1996. After being deployed to a distance of 19.5 kilometers, the tether broke and the satellite was lost. Following the mission, the remaining hardware will be de-integrated. An independent review panel has been formed to investigate the In-flight failure of the tether system with a preliminary report on its findings due in May.

BASIS OF FY 1997 FUNDING REQUIREMENT

PAYLOAD PROCESSING AND SUPPORT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Payload processing and support.....	44,000	40,600	42,700

PROGRAM GOALS

The primary goal for payload processing and support is to provide the capability to safely and efficiently assemble, test, checkout, service, and integrate a wide variety of Space Shuttle spacecraft and space experiments.

STRATEGY FOR ACHIEVING LS

The p processing and support program provides the ic p facilitie and capabilities to ı ıı ıp test ε integration of multiple payloads. servicing, transportation to tl launch i integratic and installation into the launch i Included in program are ı efficienciesgained to date, as ε as i anticipated efficiencies to reduce cost and improve customer satisfaction. s already in place have reduced processing time and error ı Workforce reductions currently in p have not impacted sch time, and the FY 1996 strategy includes plans to further reduce the workforce while mai or continuing to ı customer satisfaction trends.

MEASURES OF PERFORMANCE

Missions Supported	FY 1995 plan	FY 1995 Actual	FY 1996 Plan	FY 1996 Current	FY 1997
Space Shuttle Missions	7	6	7	8	7
Spacelab Payloads	4	3	4	4	1
Hitchhiker Experiments	10	10	TBD	9	11
Get-Away Special Payloads	7	6	TBD	15	TBD
Mir Missions	1	1	3	3	3
Other Major Payloads	6	6	3	4	5
Other Secondary Payloads		1	TBD	2	1
Expendable Launch payloads*	11	1	5	9	7

	FY 1995 plan	FY 1995 Actual	FY 1996 plan	FY 1996 Current	FY 1997 plan
Number of Payload Facilities Operating at KSC	6	7	6	6	6
KSC Payload Ground Operations (PGOC) Workforce		392		362	359

* Expendable payload launches in FY 1995 were under plan for several reasons. Technical problems with the Pegasus launches have delayed five payloads. Technical problems with the payloads and other Expendable Launch Vehicles (ELVs) have delayed launches beyond the fiscal year, many of which are planned for FY 1996.

ACCOMPLISHMENTS AND PLANS

In FY 1995. payload processing and support funding provided launch and landing payload support activities for six Space Shuttle missions and payload processing support and facilities for 26 major and secondary payloads. During FY 1995. payload processing and support was provided to Atmosphexic Laboratory for Applications and Science (ATLAS-3), Tracking and Data Relay Satellite (TDRS-G), Spacehab-3, Astronomy (ASTRO-2), Cryogenic Infi-ared Spectrometer Telescope for Atmosphere (CRISTA-SPAS). Wake Shield Facility (WSF-2), Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN 204 and 201-3), and Space Shuttle-Mir using the Spacelab module. Payload processing support was provided to the Geostationary Operational Environmental Satellite (GOES-J), an expendable launch vehicle (ELV) payload. During the year, three of eight payload processing facilities provided to Kennedy Space Center by Cape Canaveral Air Force Station were returned to Air Force responsibility.

The FY 1996 funding will provide payload processing and support for eight Space Shuttle missions and the necessary customer payload processing facilities and support for 37 major and secondary payloads. Among the payloads to be processed in FY 1996 include United States Microgravity Laboratory (USML-2), three Shuttle Mir missions (S/MM-2, 3 and 4). Space Flyer Unit Retrieval (SFU-RETR), Tethered Satellite System Reflight (TSS-1R), United States Microgravity Payload (USMP-3), SPARTAN 207/IAE, OAST FLYER, Spacehab-4, and Life and Microgravity Spacelab (LMS). Payload processing facility support will be provided to ELV payloads such as Near Earth Asteroid (NEAR). Solar Heliospheric Observatory (SOHO), and X-ray Timing Explorer (XTE). These payloads are not *only* provided by American industries and universities. but also provided in cooperation with our international partners. A major payload that involved international cooperation was 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 (used for transporting payloads at KSC) with completion anticipated within the fiscal year. Consistent with the Agency's reduction of its 'infrastructure," NASA closed the Cape Canaveral Air Force Station Hangar AO facility in January 1996.

In FY 1997, Payload Processing and Support will furnish launch and landing payload support for seven Shuttle missions as well as payload processing facilities and support for 21 major and secondary payloads. The payloads to be processed in

FY 1997 include Orfeus-Spas-2, WSF-3, Microgravity Science Laboratory (MSL-1), Shuttle Mir missions (S/MM-5, 6 and 7), Hubble Space Telescope Servicing Mission (HST-SM-2), Crista-Spas-2 and JEM Flight Demonstration (JFD). Payload processing facility support will be provided to ELV payloads such as Advanced Composition Explorer (ACE), GOES-K, MARS PATHFINDER, and Mars Global Surveyor (MGS).

BASIS OF FY 1997 FUNDING REQUIREMENT

ADVANCED PROJECTS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Advanced projects	12,200	12,200	15,200

PROGRAM GOALS

The primary goals of the program are to continue to enhance crew safety for the Space Shuttle and Space Station, to implement flight and ground systems improvements to substantially reduce cost of Space Flight operations. and to pursue technology developments to meet future Human Space Flight requirements. Secondary goals of the program are to promote transfer of advanced technologies and to develop a fully capable, diverse and motivated workforce. The Advanced Projects activity includes two program elements: Advanced Operations and Advanced Space Systems.

STRATEGY FOR ACHIEVING GOALS

The Advanced Operations program supports projects which improve ground and flight operations of current and future Human Space Flight 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 are developed to a prototype level to validate their objectives within three years. Successfully demonstrated projects are transitioned to an operational program for implementation and to private enterprise for commercial development.

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

The Advanced Space Systems program includes the Orbital Debris program and a series of flight demonstration experiments to validate critical advanced technologies in a relevant environment. The Orbital Debris effort supports projects which improve the safety of the Space Shuttle and the Space Station by measuring. modeling, and mitigating the orbital debris environment. In addition. the Orbital Debris activity includes an international cooperative program jointly funded by the space agencies of Russia, Japan, China and the European Space Agency which seeks to develop a common understanding of the debris environment. This program also develops common practices for protecting spacecraft and mitigating orbital debris environment. The Flight Demonstration program identifies and demonstrates technologies and processes which are efficient, cost-effective. reliable, and meet safety and performance requirements. Projects are matured to a protoflight level to validate their readiness to meet operational requirements. Flight demonstrations also provide training for young NASA engineers and managers with early "hands-on" flight hardware experience.

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. Many of the advanced technologies incorporated in the new integrated Shuttle/Station Mission Control Center were developed in this program. These technologies are contributing to a significant reduction of Space Flight mission operations costs. The following events represent significant future milestones in the successful completion of this program:

Advanced Operations

Delivered instrumentation component failure data sharing to the MCC Plan: 2nd Qtr FY 1995 Actual: 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 Plan: 3rd Qtr FY 1995 Actual: 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 Plan: 4th Qtr FY 1995 Actual: 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 Plan: 1st Qtr FY 1996 Actual: 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. Both tools are now in routine use in the MCC.
Deliver on-board training system STS-76/Mir mission demonstration - 3rd Qtr FY 1996	Demonstrates the capability to provide contingency and proficiency training for crews via laptop computer during long duration missions.

Demonstrate Electronic Documentation System on-board STS-76/Mir - 3rd Qtr FY 1996	Extends the 'paperless" flight document capability now available in the Mission Control Center to the flight vehicle enabling more efficient document update during long duration missions and reduced publication costs.
Complete Advanced Training -walk-in" virtual environment 3rd Qtr FY 1996	Demonstrates state-of-the art training technique which could improve efficiency and reduce cost of total immersion training previously provided by simulators and water tanks.

In the Orbital Debris activity, accurate measurements have been made of the orbital debris environment. Models have been developed to predict the changes in the environment as a function of time. Utilizing these measurements. flight rules. operational procedures new orbital debris protection systems have been developed and/or modified to improve/enhance safety during Shuttle and Space Station operations. To date, a total of 16 successful flight demonstrations have been flown. All of these demonstrations achieved their primary technical objectives. All of the flight demonstration projects that are currently under development have been manifested. Future milestones include:

Advanced Space Systems

Static Feed Electrolyzer (SFE) Flight Demonstration Critical Design Review Plan: 1st Qtr FY 1996 Revised: 2nd 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. The CDR has been delayed until March 1996 due to the lack of Anal design maturity. An assessment is underway as to the schedule impact, and recovery plans if necessary, of this delay.
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.
Orbital Debris Collector (ODC) Returned from Mir - 4th Qtr FY 1997	The ODC is an experiment to collect in situ samples of the micro debris environment from the orbit of the international Space Station to understand the sources of this debris so as to take effective steps to mitigate it.
Students for the Exploration and Development of Space Flight Demonstration (SEDSAT) 4th Qtr FY 1997	The first operational use of a low cost expendable tether to raise the altitude and extend the operational life of a University of Alabama at Huntsville designed satellite.

SFE Flight Demonstration Plan: 1st Qtr FY 1998 Revised: 3rd Qtr FY 1997 (STS-84)	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 (STS-87)	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 1995 include:

The Electronic Documentation System - Initial implementation of a 'paperless" flight document system in the Mission Control Center which will reduce the cost of document preparation and publication, improve the efficiency of document update distribution, and enable rapid document access and referencing by flight controllers, crews, and payload operators.

The Visual Prox Ops Package - A capability that allows flight controllers (and the public) to view proximity operations during Shuttle approaches to other vehicles, such as Mir. and Space Station via computer-generated animation during periods when downlinked video is not available. The capability also simulates rocket plume impingement on other vehicles during prox ops and docking. This capability was utilized to support the first Shuttle/Mir mission.

Supersonic Nozzle for Component Cleaning - Enables the cleaning of small Shuttle components, previously cleaned with CFCs which are now banned, with water. Reduces cleaning time and costs. and toxic waste.

FY 1996 will be a transition year for the Advanced Operations program. Four high leverage tasks will be completed: 1) The Electronic Documentation Project complete certification testing, transition operations to the Mission Control Center, extend its capabilities to other NASA Centers, and demonstrate its use on-board the Shuttle. 2) The Advanced Training Technologies (ATT) project will demonstrate the capability to provide contingency and proficiency training in orbit via laptop computer, and will demonstrate a "walk-in" virtual environment to provide total immersion training now done in simulators and water tanks. One of the products of the ATT project was named NASA Invention of the Year for 1995, and its project manager received the 1995 American Management Society award for outstanding technical management. 3) The Cooperating Expert Systems (COOPES) project will complete development and certification of vehicle system monitoring expert systems and of information sharing software tools for the Mission Control Center. The project received a Federal Leadership Award and a Space Act Award during FY 1995 for development of the Information Protocol. 4) The Conductive Polymer Coating Space Act Agreement will receive the final installation in its 3-year commercial development process. The corporate. university and government laboratory partners plan to complete testing of the coating and have it ready for market in 1998. Beginning in FY 1997. this successful program will be transitioned to the Space Shuttle program to help meet its cost reduction goals.

Also in FY 1996, an Advanced Development effort has been initiated to mitigate risk for the future development of a crew return vehicle. The X-CRV project is an effort to reduce the cost of crew return vehicle (CRV) for the international Space Station by developing and flight-testing critical technologies for the vehicle. The effort is an in-house, civil servant effort focused on design studies, computer analysis, subsystem component testing and limited in-flight demonstrations. Particular emphasis is placed on technologies that have the potential to reduce design and operational costs for the vehicle. This activity will continue through FY 1997.

In the Advanced Space Systems program, recent flight demonstration project accomplishments include:

The Orbital Debris Radar Calibration Spheres (ODERACS-2) flight demonstration was flown on the Space Shuttle. ODERACS-2 successfully deployed three spheres and three dipoles which were used to calibrate the Haystack Orbital Debris Radar, optical telescopes and other radars used to characterized the orbital debris environment.

The first phase (definition phase) of the International Space Welding Experiment (ISWE) with the Paton Welding Institute (PWI) in Ukraine was successfully completed. A phase 2 (hardware development) contract with PWI was negotiated for the delivery of two sets of Universal hardware as well as a work station.

The Orbital Debris program collected 1200 hours of observation of the debris environment using the Haystack Orbital Debris Radar, bringing the total observation measurements up to 4700 hours. Additional measurements of the environment were obtained from numerous Shuttle missions providing invaluable data on the nature of the micro-debris environment and its damage potential to piloted spacecraft. The liquid metal mirror telescope was moved to Cloudcroft, New Mexico. Visual observations of debris particles as small as 10 centimeters in geostationary orbit are possible using this telescope.

In FY 1997, the Haystack Auxiliary Radar and the Haystack Radar will monitor the orbital debris environment for the Space Station. Orbital debris activities will continue on characterizing changes in the orbital debris environment as a function of time and establishing measures for mitigation of debris growth trends. An international geostationary debris observing program will be initiated with participation from NASA, ESA, Russia, Japan, Australia, and other spacefaring nations. Work will begin on the design of an Extra Vehicular Activity (EVA) debris shield for protecting the Space Station crews when they are exposed to the debris environment during an N A

The Debris Capture experiment will be returned from the Mir station after approximately one year In orbit. Analysis will begin of the debris samples captured by the aero gel. The Static Feed Electrolyzer will be launched In mid FY 1997. After the completion of the flight demonstration. validation of the performance on the device will be available to Space Station. The ISWE flight demonstration will be readied for launch early in FY 1998.

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BASIS OF FY 1997 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Engineering and technical base	165,600	171,700	151,500

PROGRAM ALS

The focus of the Engineering and Technical Base (ETB) is to support the institutional capability in the operation of space flight laboratories. technical facilities. and testbeds: conduct independent safety, and reliability assessments: and to stimulate science and technical competence in the United States. 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). 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.

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 years, this consolidation 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.

Mandatoxy equipment repair and replacement will be reassessed. 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.

A *key* component of the ETB strategy will be to provide a core capability for future human space flight endeavors with fewer resources. Future budget constraints dictate that new innovative processes be adopted to meet critical ETB core requirements. In addition, non-critical capabilities will have to be streamlined or eliminated.

MEASURES OF PERFORMANCE

Laboratory facilities (KSC)	Continuing Support for 22 labs for approximately 121 applied research projects
Laboratory facilities (JSC)	Continuing support for science and engineering laboratories
Laboratory facilities (MSFC)	Continuing support for approximately 50 core laboratory areas
Propulsion Facility and Lab Facilities (WSTF)	Continuing provision of core environment to support customer base
Equipment Replacement Study Plan: 4th Qtr FY 1995 Revised: 4th Qtr FY 1995	Prioritized Replacements and Upgrades plan to be developed. Human Space Flight centers have submitted inputs to Headquarters which is being consolidated with other Field Centers for the Chief Information Officer.
Information Resources Management (IRM) Five Year Investment Plan (MSFC)- Plan: 4th Qtr FY 1995 Actual: 4th Qtr FY 1995	Consolidated Automated Data Processing (ADP) Operations of Human Space Flight centers to MSFC.
IRM Five Year Investment Plan (MSFC) - 4th Qtr FY 1996	Consolidate ADP Operations of the other Field Centers to the supercomputer. Ames Research Center is in charge of the initiative. A draft schedule is currently being reviewed, but this will be an on-going effort through FY 1997.
NASA Minority University Research and Education Program at JSC. KSC, MSFC & SSC	Award education and research grants

ACCOMPLISHMENTS AND PLANS

The institutional technical base accomplished numerous activities in FY 1995. At JSC, ETB funded the purchase of laboratory equipment and technicians, engineering workstations. calibration equipment and services. component fabrication, and Class VI computer maintenance and operations in support of the science and engineering laboratories and facilities at JSC. This ETB support ensures that JSC retains the capability to perform real-time mission analysis of flight anomalies and real-time and post-flight problem resolutions, as well as other science and engineering testing and analysis. In addition to laboratory support, ETB supports safety, reliability. and quality assurance (SR&QA) activities for the Space Shuttle and Space Station programs. JSC also continued to award ETB research grants to Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs). JSC's FY 1996 ETB funding will continue these activities at FY 1995 support levels.

At WSTF, FY 1995 ETB funding supported propulsion testing facility and other laboratory infrastructure. This core environment maintained with ETB enabled WSTF to support a customer base with testing and evaluations of spacecraft materials. components, and propulsion systems for safe human exploration and utilization of space. It enabled WSTF to perform tasks for all NASA programs as well as other Government agencies and the aerospace and medical industry. WSTF's FY 1996 ETB funding will continue these activities at FY 1995 support level.

With ETB funding, the KSC supports a core environment for 22 laboratories and 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 micro-meteoroid 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.

ETB supported KSC's 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 also developed specific techniques to specific volatile organics released by plants; and the microscopy lab analyzed the root characteristics of plants grown on flight nutrient delivery systems.

The MSFC allocation of ETB funds approximately 50 core laboratory areas. 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. ETB enabled MSFC to conduct research and development effortsrelated to advanced propulsion systems and spacecraft, as well as engineering design, systems engineering, systems integration. material and process engineering, physical science research, test and evaluation. data analysis and system simulations. As the NASA Center of Excellence in propulsion systems, in FY 1996, MSFC is undertaking an Advanced Space Transportation Technology Program, whose ultimate objective is to make dramatic reductions in the cost of boosting payloads into low-Earth orbit. Funding in the amount of $15.0 million is identifled to begin development of low-cost, small booster technologies and demonstration of rocket-based combined cycle (RBCC) hardware. Effort on low-cost small booster technologies will include avionics hardware, engine component hardware (injector. chamber. turbomachinery, valves, actuators, ducts and lines). test support and propellants for component testing. RBCC activities include test hardware fabrication. test support and propellants. Continuation of these activities through FY 1997 is provided for in the ETB program.

At SSC, ETB supported the SSC technical core laboratory operations. Although the size of the SSC institutional engineering and laboratory capability is very minimal. ETB enabled the Center to maintain the capability to conduct advanced propulsion test

technology research and development for government and commercial propulsion programs. The SSC laboratories perform activities for major NASA Space Shuttle programs, reimbursable resident agencies and Rocketdyne test operations. The SSC core laboratory environment provides 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. ETB also enables 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 as well as sensor development for engine health management and for spectral analysis. SSC's FY 1996 ETB funding will continue these activities.

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. Over 58.250 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. Approximately 3.000 Non-Destructive evaluations were performed by KSC to support the Space Shuttle and payload processing schedules. ETB provided over 15.000 units of commodity sampling and an average of 5.000 units of chemical analysis at KSC on propellants, aircraft fuels and gases. MSFC purchased predominately liquid nitrogen, the bulk of which was converted to gaseous nitrogen, and was distrlbuted 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, the institutional Safety and Mission Assurance (SRM&QA) contractor workforce to perform space flight activities at JSC. WSTF, MSFC and KSC. This workforce includes highly skilled personnel who are charged with responsibility to conduct assessments of conformance to reliability and quality standards. The ETB resources also support independent assessments of flight and test equipment and testing operations, including product assurance tasks for the International Space Station program. Surveillance of design manufacturing and testing of hardware and software was conducted to ensure compliance with NASA safety and mission assurance requirements.

Problem reporting and ALERT systems were maintained and data was provided to project, program, engineering and safety and mission assurance organizations. Problem trending, reliability trending and special safety assurance studies were accomplished in FY 1995. Finally, MSFC will continue with transition plans for contractor to civil service employees.

Information resource management (IRM) processing achieved efficiencies and improved economies of scale through the consolidation of IBM-compatible mainframes supporting administrative and programmatic automated data processing (ADP) services at the NASA ADP Consolldation Center located at MSFC. Consolidation of user requirements and information technology plans were implemented at JSC. MSFC. SSC and Headquarters. The NASA Automated Data Processing (ADP) Consolidation Center (NACC) provides supercomputing capability for its customers for engineering and scientific computer-intensive applications 7 days a week. The NACC supercomputing facility was established in FY 1994 and is managed through the MSFC NACC Project Office. The NACC supercomputing facility includes a mainframe located at MSFC and a smaller distrlbuted system located at JSC.

The NACC supercomputing customers are from JSC and MSFC. The NACC supercomputer facilities include hardware and software to conduct thermal radiation analyses, computational fluid dynamics, structural dynamics and stress analyses for NASA programs such as the Space Shuttle, X33, X34, Space Station, Reusable Launch Vehicle, certification and engineering performance evaluation of flight and test data, simulation aerodynamics and others. Supercomputing, at both JSC and MSFC, in the past was funded through ETB funding at the individual Centers. The NACC supercomputing facility is funded through ETB and programmatic funding from the participating supercomputer customers beginning in FY 1996. MSFC and JSC will continue to develop and process software applications under the new fee arrangements. NACC consolidation actions resulted in near-term cost savings of up to 3% with 42% costs savings expected for FY 1996. In FY 1995, ETB participated in the Office of Space Flight (OSF) Five-Year Investment Strategy for FY 1995 through FY 1999. to further accrue savings to space flight ADP operations.

In cooperation with the goals of the NASA Minority University Research and Education Program, ETB enables the space flight Centers to participate in programs to stimulate science and technical competence in the Nation. ETB program enabled the Centers to award (such as MSFC awarded a total of 52) education and research grants to Historically Black Colleges and Universities (HBCU), Other Minority Universities (OMU), Teacher/Faculty enhancement programs, and JSC University Research Program. Examples of awards granted include solution crystal growth in low gravity: organic fiber optic sensors: hydrazine solution disposal: atmospheric corrosion sensor: properties of ion beam deposits, and phytoalexins in plant disease.

In FY 1997, the ETB budget will initiate the first year of reductions resulting from the Agency's zero-base review. These reductions will result in a reduced level of science and engineering lab support to human space flight programs, streamlined technical operations. additional ADP consolidation activities. and reduced education and research awards funding. These ETB budget reductions will require that all Centers initiate an assessment of their range of workforce skills. analytical tools and facilities dedicated to ensure space flight institutional engineering support for future human space flight programs and the existing customer base. This assessment will focus on maintaining core support for design, development, test and evaluations, independent assessments, simulation, operations support, anomaly resolution. and systems engineering activities with reduced funding.

Science, Aeronautics
and Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1997 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 material 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 1997 BUDGET ESTIMATES
(MILLIONS OF DOLLARS)

	BUDGET PLAN		
	1995	1996	1997
SCIENCE, AERONAUTICS AND TECHNOLOGY	5,917.4	5,845.9	5,862.1
SPACE SCIENCE	2,032.6	2,032.6	1,857.3
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	467.4	488.5	498.5
MISSION TO PLANET EARTH	1,344.1	1,289.4	1,402.1
AERONAUTICAL RESEARCH AND TECHNOLOGY	845.5	845.9	857.8
NATIONAL AERONAUTICS FACILITIES	35.0	--	--
SPACE ACCESS AND TECHNOLOGY	605.4	641.3	725.0
MISSION COMMUNICATION SERVICES	481.2	441.3	420.6
ACADEMIC PROGRAMS	106.2	106.9	100.8

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

SCIENCE, AERONAUTICS AND TECHNOLOGY

[(INCLUDING RESCISSION OF FUNDS)]

For necessary expenses, not otherwise provided for, in 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, $5,862,100,000, to remain available until September 30, 1998. Chapter VII of Public Law 104-6 is amended under the heading, "National Aeronautics and Space Administration," by replacing "1997" with "1998" and "1996" with "1997."

Note.—A regular 1996 appropriation for this account had not been enacted at the time this budget was prepared. The 1996 amounts included in this budget are based on the levels pmvided in three continuing resolutions: P.L. 104-91, P.L. 104-92 and P.L. 104-99.

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

	BUDGET PLAN		
	1995	1996	1997
SCIENCE, AERONAUTICS AND TECHNOLOGY	**389.0**	**580.4**	**586.5**
SPACE SCIENCE	55.6	71.5	70.5
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	0.8	2.8	2.3
MISSION TO PLANET EARTH	174.3	290.6	293.4
AERONAUTICAL RESEARCH AND TECHNOLOGY	67.6	82.6	82.5
SPACE ACCESS AND TECHNOLOGY	48.8	62.5	65.0
MISSION COMMUNICATION SERVICES	3.7	7.0	7.3
ACADEMIC PROGRAMS	5.0	0.9	0.5
LAUNCH VEHICLES	33.2	62.5	65.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1997 ESTIMATES

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

Program		Total	Johnson Space Center	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	1995	2,032,600	3,700	11,200	321,900	0	36,300	0	1,300	105,900	760,600	561,400	230,300
	1996	2,032,600	3,700	13,300	351,600	0	71,400	0	900	91,700	687,500	563,300	249,200
	1997	1,857,300	3,600	12,000	293,400	0	77,200	0	0	92,300	679,700	467,000	232,100
Life and Microgravity Sciences and Applications	1995	467,400	117,200	29,000	126,000	0	63,700	0	1,200	72,900	200	3,800	53,400
	1996	488,500	122,300	10,200	113,400	0	73,100	0	3,400	76,200	300	13,400	76,200
	1997	498,500	102,300	13,600	114,000	0	100,300	0	3,300	83,800	200	14,300	66,700
Mission to Planet Earth	1995	1,344,100	90	3,275	5,960	155	40,643	0	25,803	14,689	1,054,416	87,650	111,419
	1996	1,289,400	0	4,900	3,300	100	39,788	2,200	12,505	66,200	913,744	44,998	201,665
	1997	1,402,100	0	4,500	2,000	0	13,200	2,700	8,187	51,300	1,036,602	47,063	236,548
Aeronautical Research and Technology	1995	845,500	0	100	2,000	300	243,400	46,300	289,200	244,200	4,400	2,400	13,200
	1996	845,900	0	0	2,100	0	203,600	55,100	306,900	258,900	4,300	2,000	13,000
	1997	857,800	0	0	2,100	0	204,600	67,600	307,000	263,800	4,700	1,700	6,300
National Aeronautic Facility	1995	35,000											35,000
	1996	0											
	1997	0											
Total Aeronautical Research and Technology	1995	880,500											
	1996	845,900											
	1997	857,800											
Space Access and Technology	1995	605,400	24,600	5,900	149,900	17,700	31,500	600	56,600	55,700	35,200	69,000	158,700
	1996	641,300	34,600	6,300	185,800	20,100	29,900	4,400	49,300	64,800	36,500	69,600	140,000
	1997	725,000	25,400	7,100	318,600	19,700	41,300	6,800	50,800	54,100	33,100	60,600	107,500
Mission Communication Services	1995	481,200	50	0	3,000	0	0	15,100	0	2,000	262,900	196,500	1,650
	1996	441,300	0	0	3,000	0	0	13,900	0	1,900	226,200	194,500	1,800
	1997	420,600	0	0	1,300	0	0	15,700	0	2,000	201,800	198,100	1,700
Academic Programs	1995	106,200	1,257	987	3,763	1,860	5,579	119	2,695	2,281	6,146	2,295	79,218
	1996	106,900	2,128	1,661	4,674	2,323	7,226	574	3,528	2,440	7,012	2,677	72,657
	1997	100,800	1,984	1,633	4,248	2,236	6,463	572	2,834	1,900	6,260	2,296	70,374
TOTAL SCIENCE, AERONAUTICS AND TECHNOLOGY	1995	5,917,400	146,897	50,462	612,523	20,015	456,122	62,119	376,798	497,670	2,123,862	923,045	647,887
	1996	5,845,900	162,728	36,361	663,874	22,523	425.014	76,174	376,533	562,140	1,875,556	890,475	754,522
	1997	5,862,100	133,284	38,833	735,648	21,936	443,063	93,372	372,121	549,200	1,962,362	791,059	721,222

Space Science

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

SUMMARY OF RESOURCES REQUIREMENT

	FY 1995	FY 1996 (Thousands of Dollars)	FY 1997	Page Number
* Advanced x-ray astrophysics facility	224,300	237,600	178,600	SAT 1.1-8
* Cassini	255,000	191,500	106,700	SAT 1.1-12
* Relativity mission	50.000	51,500	59,600	SAT 1.1-15
* Global geospace science	40,000		--	SAT 1.1-18
Payload and instrument development	66,000	30,700	16,900	SAT 1.1-20
* Explorers	120,400	132,200	135,000	SAT 1.1-26
* Discovery	129,700	102,200	74,800	SAT 1.1-32
* Mars surveyor	59.400	111,900	90,000	SAT 1.1-37
New millennium	(10,500)	30,000	21,500	SAT 1.1-40
Mission operations and data analysis	544,600	563,800	592,400	SAT 1.1-44
Supporting research and technology	220,400	238,900	259.200	SAT 1.1-54
suborbital program	67.200	88,000	69.100	SAT 1.1-67
Launch services	255,600	254,300	253,500	SAT 1.1-71
To	2,032,600	2,032,600	1,857,300	

- Total Cost information is provided in the Special Issues section

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

I OF SPACE SCIENCE

SUMMARY OF RESOURCES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Distribution of Program Amount by Installation			
Johnson Space Center	3.700	3,700	3,600
Kennedy Space Center	11.200	13,300	12,000
Marshall Space Flight Center	321,900	351.600	293,400
Ames Research Center	36.300	71,400	77.200
Langley Research Center	1,300	900	--
Lewis Research Center	105.900	91.700	92,300
Goddard Space Flight Center	760,600	687,500	679,700
Jet Propulsion Laboratory	561,400	563.300	467,000
Headquarters	230.300	249.206	232.100
To	2.032.600	2.032.600	1.857.300

OFFICE OF SPACE SCIENCE

PROGRAM GOALS

The Office of Space Science seeks to expand our understanding of the origin and evolution of the universe, the fundamental laws of physics, the formation of stars and planets, and the processes by which our solar system developed. Space Science seeks to discover and investigate extra-solar planets. and to determine the origin and evolution of life in the universe. The exploration and research activities of this program seek to answer specific questions within the five fundamental themes identified as goals of the Space Science program. These themes are:

- The Sun-Earth Connection: determine the processes that drive the Sun and govern its effects on Earth's environment and the heliosphere;
- The Structure and Evolution of the Universe: discover the origin, evolution and fate of the universe, galaxies, stars and planets.
- The Exploration of the Solar System: determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system.
- The Astronomical Search for Origins and Planetaxy Systems: discover and investigate plane —— systems around other stars for evidence of habitable planets.
- The Origins and Distribution of Life in the Universe: determine the origin and distribution of life in the universe.

STRATEGY FOR ACHIEVING LS

The Sun Earth connections theme is focused upon naturally occurring plasmas, the physical state which comprises 99% of all matter in the universe. The relatively cool plasmas in the plane —— ionospheres, the hot plasma of the Sun, the 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 structure and evolution of the universe theme is concerned with the universe beyond our solar system. Objects studied 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 within this theme, and are the target of many ground-based and space-based research programs. Space-based research is important in achieving this goal because astronomical observations from space avoid image distortion created by the Earth's atmosphere. Many wavelengths critical to astrophysics are obscured and some of these critical wavelengths cannot be observed from the surface of the Earth at all.

The exploration of the solar system theme is focused upon determining the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system. It is also focused upon understanding the Earth better through comparative studies with the other planets, understanding how the appearance of life in the solar system is related to the chemical history of the solar system, and providing scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been *highly* successful based on a strategy that places a balanced emphasis on the Earth-Like inner planets, the giant gaseous outer planets, and the smaller bodies (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.

The astronomical search for origins and planetary systems theme is focused upon the search for planetary systems around other stars and for evidence of habitable planets, discovering the origins of planetary systems, stars. and galaxies.

The origin and distribution of life in the universe theme is focused upon answering several key questions: What generated the conditions for life on Earth? Was there ever life elsewhere in the solar system? Is there life elsewhere in the universe? We have learned that life may be a common consequence of planet formation and that planets may be common in the universe. NASA is fostering research on how life begins, how the ingredients for life are distributed in the universe, and how we *can* find life in our solar system and elsewhere. Life arose very early on Earth and the starting materials for life could have come from the planet's atmosphere, from hydrothermal vents (such as in the deep ocean) and from space - organic material brought with meteorites, comets and cosmic dust particles. These primitive materials represent a sample of the early solar system and a critical clue to the nature of the primordial Earth. Development of our ideas about how life originates will depend on comparisons between Earth and other planets. Though the Earth is the only known abode for life, the knowledge we can gain here on the origin of life is limited, erased by life itself and by geological processes. Perhaps the best evidence of the chemical steps leading to the origin of life and/or of the origin of life itself, may be found on the planet Mars (the conditions for life existed on early Mars at the same time that life began on Earth). If not on Mars, then perhaps elsewhere.

Through exploration aimed at answering these questions, NASA brings the benefits of space science to the American public and to the world's scientific community. The primary products of space science are knowledge and discoveries about the universe in which we live and the laws that govern it. The process by which we acquire knowledge and make discoveries is exploration. These explorations are achieved through a combination of spacecraft missions, instruments and payloads flown on international and U.S.-sponsored satellites and Shuttle/Spacelab flights, as well as 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 Advanced X-ray Astrophysics Facility (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. AXAF, initiated in N 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.

The Cassini program will provide unprecedented information on the origin and evolution of our solar system. It will help tell 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, the mission 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.

Full scale development of the Relativity Mission was initiated in N 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.

The Global Geospace Science (GGS) program is part of the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program, which is a broad initiative to conduct advanced observations and study of the Sun and Earth's geospace. NASA's two GGS spacecraft, Wind (launched November 1994) and Polar, together with Japan's Geotail (launched July 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, Polar at Earth's poles. and Geotail at a point where the Earth's magnetic region tails away. Polar was launched in February 1996.

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 Europe's Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft, and Japan's Geotail spacecraft. Geotail was launched successfully in 1992: SOHO was launched successfully in December 1995. Cluster's launch is scheduled for May 1996. Payload and Instrument Development also supports U.S. participation in the Tethered Satellite System (TSS) science program, a cooperative program with Italy that will contribute to our knowledge about geospace. and Astro-E, a Japanese x-ray mission.

Explorer missions are selected to conduct investigations of an exploratory or survey nature, or to achieve specific objectives that do not require the capabilities of a large spacecraft or observatory. The Advanced Composition Explorer (ACE), the Submillimeter Wave Satellite (SWAS), the Fast Auroral Snapshot (FAST). the Transition Region and Coronal Explorer (TRACE), the Wide-field Infrared Explorer (WIRE), and the Far Ultraviolet Spectroscopy Explorer (FUSE) missions are all currently under development within the Explorer program.

The Discovery missions respond to the need for low-cost, quick design-to-flight planetary missions. 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 planetary science program in the future. Mars Pathfinder will launch in December 1996 and will test innovative entry. descent and landing systems, and deliver a modest science payload to the Martian surface, including a microrover developed under the Space Access and Technology program. The s p a c e d will collect spacecraft performance data during these activities as well as atmospheric pressure, temperature and density information. NEAR's launch on February 17, 1996, will initiate the flight phase of this mission to conduct a comprehensive study of the asteroid 433 EROS, including its physical and geological properties and its chemical and mineralogical composition. The spacecraft will also encounter the main belt asteroid Iltya in August 1996 en route to rendezvous with 433 EROS in December 1998.

The Mars Surveyor program began in FY 1994 with the development of the Mars Global Surveyor, an orbiter which will obtain much of the data that would have been obtained from the 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 11 launch vehicle. This mission is to be succeeded by a series of small orbiters and landers which will make in-situ measurements of the Martian climate and soil composition. An orbiter launch is planned in December 1998, followed by a lander launch in January 1999, two launches in the February 2001 opportunity. and launches in the 2003 and 2005 opportunities.

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 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 Surveys (ACS) 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. Development of the Stratospheric Observatory for Infrared Astronomy (SOFIA), a cooperative program with Germany, will continue in FY 1997 following selection of the prime contractor during the summer of 1996. SOFIA will accomplish infrared studies of the birth and death of stars. the formation of planetary systems, the chemical make-up of star-forming clouds in the Milky Way galaxy, the nature of the energy sources in other galaxies. and the nature of the outer bodies in our own solar system. The Kuiper Airborne Observatory (KAO) made its last science flight in October 1995. and has been retired in order to minimize the additional investment required for SOFIA.

The Research and Analysis program provides a solid basis of supporting research, new technology development, 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. Planning and technology development activities related to the Space Infrared Telescope Facility (SIRTF) are continuing. 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.

The Information Systems program 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.

hunch services funding budgeted within the Space Science program supports Pegasus launch services for the SMEX missions (FAST, SWAS, TRACE, WIRE): Medium-lite class launch services for FUSE Delta launch services for Polar, ACE, XTE, MGS, NEAR. and Pathfinder; Atlas launch services for SOHO; an Inertial Upper Stage (IUS) for AXAF; and Titan IV launch services for *Cassini.*

Beginning in FY 1997. the Physics and Astronomy. and Planetary Exploration budget line items will be consolidated into one budget line item, Space Science. This consolidation reflects the recent reorganization of the Office of Space Science. The level of detail visible has not changed: individual programs under the old structure are still identified under the new structure, without any change in content.

BASIS OF FY 1997 FUNDING REQUIREMENT

ADVANCED X-RAY ASTROPHYSICS FACILITY

	FY 1995	FY 1996	FY 1997
		(Thousands of Doh)	
Advanced x-ray astrophysics facility development*.....	224,300	237.600	178.600

* 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 contrlbutions 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 Callbration Facility at MSFC in 1991, and the x-ray results validated the metrology and polishing. With the success of this Verification Engineering Test Article (VETA) # 1 demonstration, the program proceeded fully into design and development.

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, a 15-year mission in low-Earth orbit, and 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 underway, and funding for Astro-E activities is requested within the Payload and Instrument Development line.

MEASURES OF PERFORMANCE

Instrument CDRs Plan: April 1995 Accomplished: July 1995	CDR's for two of the four instruments were not completed until July 1995, but critical path slack was not affected. Reviews confirmed that instrument designs are sufficiently mature, meet all critical performance and interface requirements, and pose acceptable levels of technical, cost and schedule risk to the overall program.
AXAF Science Center (ASC) Critical Design Review (CDR) Plan: July 1995 Accomplished: July 1995	Review validated the overall maturity of ASC design, and ensured 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 Plan: December 1995 Accomplished December 1995	Review verified 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 Plan: February 1996 Current: February 1996	This major milestone is on schedule. The review will assess the validity and maturity of observatory design as a functionally integrated system in terms of subsystem compatibility, interface requirements and ability to meet all established perfoxmance criteria within acceptable levels of technical, cost and schedule risk
Science Instrument Module (SIM) completed Plan: April 1996 Current: January 1997	Fabrication of the Science Instrument Module completed at Ball Aerospace. The SIM will house the two focal plane science instruments on *AXAF.* Completion of this milestone is now scheduled for January 1997; SIM participation in XRCF testing is currently under review.

Deliver flight instruments Plan: August 1996 Current: HRC in September 1996 ACIS in December 1996	Flight instruments shipped upon completion of integration and test activities for integration into the SIM (see above). The HRC is expected to be available in September 1996, and delivery of ACIS is now expected to occur in December 1996. ACIS participation in XRCF testing is currently under review.
X-ray calibration begins at MSFC Plan: January 1997	Tests will verify HRMA mirror alignment and compare technical performance of mirrors and science instruments against predicted values. There are no current plans to slip XRCF tests, but ACIS and SIM participation in XRCF testing is currently under review.
Complete HRMA/Instrument Callbration Plan: April 1997	Verification of end-to-end optical performance. This effort is currently on schedule.
Begin Observatory assembly and test Plan: October 1997	Initiate integration of completed spacecraft with telescope/instruments at TRW, followed by full-up systems testing (thermal-vacuum,acoustic. et al). On schedule.
Deliver Observatory to Kennedy Space Center (KSC) Plan: June 1998	Observatory integration and systems testing completed at TRW. Begin integration with upper stage, Anal performance testing, and integration in Shuttle cargo bay. On schedule.
Launch Observatory Plan: September 1998	Shuffle deployment into low-Earth orbit followed by upper stage delivery to highly elliptical operational orbit. Hardware checkout followed by initiation of science observations. On schedule.

ACCOMPLISHMENTS AND PLANS

For the second year in a row. *AXAF* has not lost a day of schedule on the critical path towards launch. A number of technical issues with the AXAF CCD Imaging Spectrometer (ACIS) instrument have resulted in the delay of its planned delivery date. Critical Design Reviews (CDRs) for the four science instruments were not completed until July 1995, later than expected a year ago. However, the schedule still supports initiation of x-ray calibration tests at MSFC in January 1997. Coating of the mirrors began in April 1995, two months early. and was completed in January 1996. The quality of the coating has been outstanding with reflectivity exceeding requirements, further increasing technical performance margins. Meanwhile. program costs are at or below planned levels. and reserves (as a percentage of work to go) are holding steady.

Detailed design activities for the spacecraft were completed on time in December 1995. and fabrication of the flight structure will begin in early 1996. The spacecraft Structural Test Article was completed by January 1996. and static testing is scheduled to be completed by April. The CDR for the entire *AXAF* Observatory 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.

With the funds requested for FY 1997. AXAF-I development will be more than 93% complete. Successful completion of x-ray calibration in early CY 1997 will be followed by final assembly and test of the telescope and the spacecraft over the last half of the fiscal year.

CASSINI DEVELOPMENT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Cassini development *	255.000	191.500	106,700

• 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. It will help tell 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, the mission 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 four years of 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 spacecraft will also obtain a radar map of most of Titan's surface.

The Jet Propulsion Laboratory (JPL) has been assigned responsibility for managing the Cassini Project and for developing the spacecraft. NASA also has four partners in the Cassini project: the Department of Defense/Air Force is constructing a Titan IV Centaur launch vehicle: the Department of Energy is contributing the Radioisotope Heater Units (RHUs) and Radioisotope Thermoelectric Generators (RTGs) for the mission: the European Space Agency (ESA) is providing the Huygens probe; the Italian Space Agency (ASI) is contributing the High Gain/Low Gain Antenna for the spacecraft and elements of the radar mapper.

PERFORMANCE MEASURES

Ground System Critical Design Review Plan: February 1995 Accomplished: 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 Plan: March 1995 Accomplished: March 1995	Provide approval to finalize design and begin full scale hardware development.
Development Test Model Static and Modal Tests Plan: April thru November 1995 Accomplished: April thru November 1995	Simulates and tests spacecraft launch environment to assure its survivability from acoustic and dynamic stresses.
Huygens Probe Crltical Design Review Plan: September 1995 Accomplished: 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 Plan: February 1996 Current: February 1996	Engineering model delivery to JPL is critical requirement for interface testing with the spacecraft.
Start System Level Tests Plan: May 1996 Current: May 1996	Integration, test and checkout of flight hardware and instruments.
Deliver Flight Model Science Instruments Plan: July 1996 Current: July 1996	Delivery of night model instruments to JPL for integration with the spacecraft.
Start Spacecraft Environmental Tests Plan: October 1996 Current: October 1996	Tests entire spacecraft performance in a simulated mission environment to assure proper operation in space.

Ship spacecraft to KSC Plan: April 1997 Current: April 1997		Complete system level integration and test activities. Begin integration with Titan IV/Centaur launch vehicle at Kennedy Space Center (KSC).
Spacecraft launch Plan: October 1997 Current: October 1997		Development phase complete. Initiate spacecraft checkout and cruise operations.

ACCOMPLISHMENTS AND PLANS

In FY 1995. Cassini continued in the fabrication and test phase. Instrument Final Design Reviews were completed, and fabrication of flight instruments was underway. The Ground System critical Design Review was completed. and development of hardware essential for spacecraft operations was underway. Spacecraft flight structure Static and Modal tests were completed, and integration of flight subsystems and cabling was underway. The Huygens Probe Critical Design Review was completed, and integration and testing of the flight Huygens Probe was underway. Cost reserves, which *are* provided in developmental programs to offset technical difficulties, remained healthy. In addition, External Independent Readiness Reviews were conducted on the Spacecraft, Instruments, High Gain Antenna, and Huygens Probe to ensure the entire Cassini program remains healthy and on schedule.

Cassini spacecraft flight system integration will continue through the first half of FY 1996. Engineering model instruments will be delivered in mid-FY 1996 for integration and test with the spacecraft systems. Flight model instruments will be delivered in late FY 1996 for integration with the spacecraft in preparation for spacecraft environmental tests. ESA will also deliver the Engineering Model Huygens Probe in early FY 1996 for integration and test with the spacecraft, and Italy will deliver the protoflight High Gain Antenna.

In FY 1997, Cassini system-level and environmental testing will continue. All spacecraft and Instrument flight systems will complete testing early in FY 1997. The spacecraft, instruments, and the flight Huygens Probe will be delivered to KSC in mid-FY 1997 for launch-site integration and test in preparation for the October 1997 launch.

BASIS OF FY 1997 FUNDING REQUIREMENT

RELATIVITY MISSION

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Relativity mission development*	50.000	51,500	59,600

* Total cost information is provided in the Special Issues section

PROGRAM GOALS

The purpose of the Relativity Mission (also known as Gravity Probe-B) 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 dragging of space has never been measured, and the geodetic effect 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 frame dragging and geodetic 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.

In addition, the Relativity Mission 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 Relativity Mission 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). The gyros will be encased in an 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). The system will maintain 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 the Relativity Mission 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 Relativity Mission 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 the Relativity Mission, 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 II launch vehicle.

MEASURES OF PERFORMANCE

Ground Tests - 1A Start Plan: February 1995 Accomplished: February 1995	Tested the operation of Probe-B protoflight model of the science Instrument under cryogenic conditions. Validated operations procedures and confirmed satisfactory overall systems performance.
Probe C CDR Plan: July 1995 Accomplished March 1995	Confirmed that the design is of sufficient maturity and detail, and is compatible with established Interfaces (thermal. structural, etc.). The design was frozen prior to initiation of full-scale hardware fabrication.
Spacecraft PDR Plan: November 1995 Accomplished: March 1995	LMSC-developed spacecraft bus will house the Dewar, Probe, and Science Instrument. Review determined overall maturity of design, assuring that all critical Interfaces and performance criteria have been met. Successful completion allowed initiation of detailed design activities at the subsystem level.
Science Instrument Assembly (SIA) Preliminary Design Review (PDR) Plan: January 1996 Accomplished: September 1995	The SIA is a quartz block that houses the quartz gyros. proof mass, electronic pickup sensors, and supporting mechanisms. Review assessed overall design maturity, compatibility with established Interfaces, and ability to achieve critical performance requirements.
Flight Model Dewar Delivery Plan: November 1996	Delivery of the largest Hellum Dewar ever made for a science mission. Ready for Integration with the Probe B prototype for the second series of performance tests. Expected to be accomplished early.
Ground Tests-2A start Plan: June 1997	Conduct the third series of performance tests using the flight model dewar and Probe B prototype. Expected to be accomplished early.

ACCOMPLISHMENTS AND PLANS

The program continues ahead of the baseline schedule to launch the Relativity Mission by October 2000. The flight dewar is nearing completion ahead of schedule and advances have been made in the scientific payload design. The second series of ground tests (GTU-1A) demonstrated the proper functioning of many aspects of the design. The third series of ground tests (GTU-2A), which are scheduled to start in June 1997, will incorporate the flight dewar and will transition later (following the delivery of the flight probe, which interfaces the science payload to the dewar) into the final series of ground tests.

The spacecraft development has also made outstanding progress. The PDR was held seven months ahead of schedule, and the spacecraft's unique thrusters and its balancing mechanisms have passed several qualification tests. The spacecraft CDR (planned for October 1997) is also likely to be accomplished significantly ahead of schedule.

A comprehensive review by the National Academy of Science validated the technical feasibility and scientific merits of the Relativity Mission. and concluded that the ".. project [is] well worth its remaining cost to completion."

BASIS OF FY 1997 FUNDING REQUIREMENT

GLOBAL GEOSPACE SCIENCE

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Global geospace science	40,000	--	--

PROGRAM GOALS

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.

STRATEGY FOR ACHIEVING GO

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 in 1996.

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 will use a total of nineteen instruments to make simultaneous measurements 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 influence 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 was launched in February 1996.

PERFORMANCE MEASURES

Polar Thermal/Vacuum Test Plan: March 1995 Accomplished: March 1995	Successful thermal/vacuum and thermal balance testing with fully operational night software was completed on time.
Polar C&DH Reintegration plan: June 1995 Accomplished: June 1995	This milestone was completed when all command and data handling (C&DH) components were fully refurbished, fully tested at the box level, and mechanically reintegrated with the Polar Laboratory.
Polar POCC V&V Test (Part 1) Plan: August 1995 Accomplished: August 1995	Comprehensive testing of ground procedures for launch and early orbit sequences, instrument activation, mission operations, and contingency modes were conducted via the GSFC Payload Operation Control Center (POCC) while the Laboratory was located in the high bay at Martin Marietta. This test was completed on time prior to final Laboratory environmental tests.
Polar POCC V&V Test (Part 2) Plan: September 1995 Accomplished September 1995	This test was similar in scope to POCC V&V Test (Part 1) but occurred with the Laboratory in nearly full flight configuration after final environmental tests. Completed on time.
Polar Arrival at VAFB Plan: October 1995 Accomplished: October 1995	Completed on time when the fully integrated and tested Polar Laboratory was delivered on dock at Vandenberg Air Force Based (VAFB).
Polar launch Plan: December 1995 Accomplished: February 1996	Mission to study plasmas, energetic particles and fields in the high-latitude polar regions. Launched on February 23, 1996.

ACCOMPLISHMENTS AND PLANS

Following the successful launch of Wind in November 1994, Polar work resumed at full speed. As noted above. all work has continued on schedule, with costs slightly below plan. Polar was shipped to the launch site, Vandenberg Air Force Base (VAFB), on schedule. Polar launched on February 23. 1996, two months later than expected a year ago, due to launch vehicle concerns. The costs of this launch delay can be absorbed within the existing budget, due to savings achieved over the past year.

BASIS OF FY 1997 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Collaborative solar terrestrial research	23.300	--	--
Tethered satellite system	3,700	5,700	--
Astro-E	10,000	7,400	5,600
Mars instruments	2.100	1,400	600
Shuttle/international payloads	26,900	16,200	10,700
To	66.000	30.700	16.900

PROGRAM GOALS

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 Sun-Earth connections, the structure and evolution of the universe, and exploration of the solar system.

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) science initiative. Whereas the U.S. GGS program will deploy Polar in February 1996 (to complement Wind, launched in November 1994), COSTR provides U.S. instruments for flight aboard foreign spacecraft. The latter include Japan's Geotail mission and the European Space Agency's (ESA) Solar Heliospheric Observatory (SOHO) and four Cluster spacecraft. Geotail was launched in July 1992 and SOHO was launched in December 1995, and they are operating well. SOHO will (1) study the solar interior by measuring oscillations of the solar surface and (2) investigate the hot outer atmosphere of the Sun that generates the variable solar wind and the W and x-ray emissions affecting the Earth's upper atmosphere, geospace environment and heliosphere. The Cluster mission will study the small scale structures in the Earth's magnetosphere, with the four Cluster spacecraft scheduled for launch in May 1996. 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 Tethered Satellite System (TSS) program is an international cooperative project with the Italian government. The TSS was flown aboard the shuttle in July-August 1992. TSS performs space plasma experiments while also investigating the dynamic forces acting upon a tethered satellite. The TSS payload was reflown aboard the shuttle in February 1996.

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.

The Payload and Instrument Development program also supports several other international and U.S. development projects. These include 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); the Satelite de Aplicaciones Cientificas-B (SAC-B). the first Argentinean spacecraft; the High Energy Transient Experiment (HETE, 1996), 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; portions of two instruments to be flown on Europe's X-ray Mirror Mission (XMM, 1998); participation in Europe's International Gamma Ray Astrophysics Laboratory (INTEGRAL): participation in the German Equator-S program; and the Air Force's Solar Mass Ejection Imager (SMEI).

ORFEUS/IMAPS, which flew aboard the Shuttle in the summer of 1993 and is scheduled to be reflown in late 1996, 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.

SAC-B and HETE will be launched together on a single Pegasus rocket. SAC-B is a collaborative program with the Argentines. Although primarily an engineering test of the first flight of an Argentine satellite, the mission will use an Argentine instrument to observe hard x-rays from solar flares and use a U.S. instrument to survey diffuse x-ray emission over a major portion of the sky. 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 contrlbutions 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 than can be achieved on the ground. VSOP and Radioastron each have 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. XMM science will be complementary to the U.S. Advanced X-ray Astrophysics Facility (AXAF). XMM's higher through-put (i.e., higher number of photons collected) will allow somewhat better spectroscopy of faint sources, while AXAF will excel at high resolution imaging. XMM has a lifetime goal of 10 years.

The ESA INTEGRAL mission will perform detailed follow-on spectroscopic and imaging studies of objects initially explored by the Compton Gamma Ray Observatory. Its enhanced spectral resolution and spatial resolution in the nuclear line region will provide a unique channel for the investigation of processes -- nuclear transitions, e-/e+ annihilation, and cyclotron emission/absorption -- taking place under extreme conditions of density. temperature, and magnetic field. U.S. participation is expected to consist of co-investigators on hardware integration, mission scientists, and a provision for ground tracking and data collection. Launch is expected in 2001.

NASA is providing parts of three instruments. an apogee kick motor, and tracking and telemetry support for the DARA/MPI Equator-S mission, to be launched piggyback on the Ariane IV in early 1997. Equator-S will complementring current energy storage data for the GGS/ISTP ensemble of missions.

SMEI is a cooperative U.S. *Air* Force mission, under the Space Test program, and is scheduled for launch in 1998. SMEI incorporates new technology and design concepts, and will work in coordination with other Space Physics missions to establish comprehensive relationships between solar drivers and terrestrial effects.

The Jet Propulsion Laboratory (JPL) will provide two Mars Oxidation (MOx) experiments, one for flight aboard each of the two landers. To conserve mass. power and space, these experiments will share common electronics subsystems with German and Russian instruments. The oxidation investigation 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. U.S. scientists are also involved in many of the other science instruments provided by our foreign partners.

MEASURES OF PERFORMANCE

Astro-2 launch man:	March 1995	Successful ultraviolet astronomy mission aboard the shuttle.
Accomplished	March 1995	

SOHO launch Plan: October 1995 Accomplished: December 1995	Launched successfully in December 1995. Delay due to launch vehicle concerns.
SAC-B/HETE launch Plan: November 1995 Current: TBD	Delayed pending Pegasus launch vehicle recovery.
Cluster launch Plan: November 1995 Current: May 1996	Delayed by ESA until May 1996 due to Ariane-V launch vehicle problems.
TSS launch Plan: February 1996 Accomplished: February 1996	Operations conducted aboard Shuttle mission STS 75.
VSOP launch Plan: September 1996 Current: September 1996	Instrument/spacecraft integration and test completed: Japanese launch.
Astro-E: Engineering model spectrometer delivery Plan: April 1996 Current: April 1996	With the delivery of this unit, the construction and test procedures needed for the flight unit will have been validated. The unit provided to the Japanese will serve to test system interfaces and allow complete systems tests to be run.
First mirror delivered to Japan Plan: October 1996	With the delivery of the first mirror, the construction. assembly and test procedures will have been completely demonstrated. Subsequent development of the next four mirrors will follow a known path. The Japanese will be able to test out system interfaces, conduct environmental tests, and conduct complete systems tests.
Flight model spectrometer completed Plan: July 1997	This task concludes the XRS instrument construction phase and begins a period of validation. testing and calibration prior to delivery of the instrument to Japan in 1998.

Mars Instruments:

Deliver MOx Instruments Plan: April 1995 Accomplished: November 1995		Complete refurbishment of MOx instruments with upgraded electronics. Ship to Russia for final integration with rest of science payload in support of November 1996 launch. Completed November 1995. No impact to integration with Russian lander.
Deliver MOx Sensor Heads Plan: May 1996 Current: May 1996		Provide two refurbished MOx sensor heads to Russia for spacecraft integration.
Spacecraft launch Plan: November 1996 Current: November 1996		Development phase complete. Initiate mission operations.

ACCOMPLISHMENTS AND PLANS

SOHO was successfully launched in December 1995. The costs of the two-month launch delay have been absorbed within the existing budget, due to savings achieved over the past year. The spacecraft is working well and will arrive at its duty station between the Sun and the Earth in March 1996. All four Cluster instruments have been shipped to the launch site for processing. Cluster's launch date has been delayed by ESA from 11/95 to 5/96 due to Ariane V engine test problems.

Reflight of the TSS satellite and instrument payload on the Shuttle is still expected in February 1996.

The Astro-E effortmoved into the development phase in FY 1995, with the completion of the X-Ray Spectrometer (XRS) Preliminary Design Review by GSFC. Fabrlcation of the engineering model was begun, and delivery of this instrument test model to the Japanese is planned for April 1996. Fabrlcation of the flight model will begin shortly afterwards, and it will be completed in July 1997. Verification and environmental tests will be completed by October 1997. Design work for the five mirrors which will be supplied to the Astro-E mission has been completed by the GSFC Mirror team, and fabrication has begun. Delivery of the first mirror to the Japanese is scheduled for October 1996, with the second and third mirrors following within one year. The project is on schedule for a February 2000 launch.

Delays in returning the Pegasus launch vehicle to flight status make it difficult to predict when SAC-B and HETE will be launched, but it currently appears unlikely to occur before December 1996. The First Announcement of Opportunity (AO) for international competition for observing time on the SVLBI program was released in the June 1995 and proposals are currently being evaluated. Initial VSOP operations are scheduled to begin in September 1996. XMM flight model components are to be shipped by June 1997 in support of a launch in December 1999.

Astro-2 data analysis activities will continue through FY 1996.

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, the Russian launch on a Proton launch vehicle was slipped two years. Consequently, the hardware status and delivery plans for the instruments were revised consistent with the launch delay. In FY 1995. MOx instruments were refurbished with upgraded electronics and shipped to Helsinki in May 1995 for spacecraft testing and integration. The MOx sensor heads will also be refurbished and shipped to Russia for spacecraft integration in May 1996 for a November 1996 launch. The 1 year prime mission will begin upon arrival at Mars in September 1997. The JPL has been designated to handle data processing and dissemination of MOx data from the Mars '96 mission. The FY 1996 funding is provided. therefore, to establish science data formatting, archival and dissemination requirements prior to initiation of the prime mission in September 1997. The FY 1997 funding provides ongoing support for the U.S. science investigators associated with all aspects of the science payload.

BASIS OF FY 1997 FUNDING REQUIREMENT

EXPLORER PROGRAM

	FY 1995	FY 1996	FY 1997
		[Thousands of Dollars)	
X-ray timing explorer	21,600	--	--
Advanced composition explorer.	44,100	31.500	24,700
Far ultraviolet spectroscopic explorer	--	39,000	39,600
Medium explorers	--	--	19,800
small explorers	41,000	39.500	38,700
Explorer planning..	13,700	22.200	12.200
'Total	120.400	132.200	135.000

* 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. Explorer missions are categorized by size, starting with the largest, Delta-class, moving down through the Medium-class (MIDEX), the Small-class (SMEX) and the University-class (UNEX) missions. As part of NASA's efforts to reduce the cost of Explorer missions, no new Delta-class missions are budgeted. NASA also funds 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.

Funding for MIDEX mission studies, UNEX mission development. and the technology development program is budgeted in the Explorer Planning line.

Delta Class

The Anal Delta-class mission still in development, the Advanced Composition Explorer (ACE), was initiated in November 1993, and is scheduled for launch no later than December 1997. This space physics mission 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 have better collecting power than 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 of ACE is provided by the Johns Hopkins University Applied Physics Laboratory. with project management by GSFC. Foreign participation on ACE includes the University of Bern and the Max Planck Institute, which provide instrument components and a flight data system shared by three instruments. respectively.

Medium Class

To facilitate more frequent flights. the new Medium-class Explorer (MIDEX) program is being initiated. MIDEX missions will cost under $70 million (FY 1994 dollars). MIDEX missions will be launched aboard a new Med-Ute-class launch vehicle. NASA plans to launch the first two MIDEX missions in late CY 1999 and 2000. In March 1995. NASA released an Announcement of Opportunity for participation in these missions, and we expect to start development in FY 1997.

Development of the Far Ultraviolet Spectroscopy Explorer (FUSE) began early in FY 1996. The FUSE mission, previously planned as a Delta-class mission. was restructured in order to reduce costs and accelerate the launch date from CY 2000 to late CY 1998. Although not a MIDEX mission, FUSE can be seen as a transitional step towards the MIDEX program. FUSE will conduct high resolution spectroscopy in the far ultraviolet region. Major participants include the Johns Hopkins University. the University of Colorado, and UC-Berkeley: Orbital Sciences Corporation has been selected by JHU as the spacecraft developer. Canada will provide the fine error sensor assembly, and France will provide holographic gratings. GSFC will provide management oversight of this Principal Investigator-managed mission.

Small Class

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 Pegasus launch vehicles. These SMEX missions are managed by GSFC, where the spacecraft are developed in-house.

The Fast Auroral Snapshot (FAST) Small Explorer initiated development in 1991. The launch of FAST was delayed from September 1994 to July of 1996 due to failure of a Pegasus launch vehicle. FAST will provide high resolution data on the Earth's auroras and on how electrical and magnetic forces control them. The flow of electrons, protons, and other ions will be studied with greater sensitivity and spatial discrimination and faster sampling than ever before, using five small, university-provided instruments. FAST data will be integrated with the results of other Earth observing satellites and ground observations. Major participants include UC-Berkeley, the Lockheed Palo Alto Research Laboratory. the University of New Hampshire, and UC-Los Angeles.

The Submillimeter Wave Astronomy Satellite (SWAS) Small Explorer initiated development in 1991, and is scheduled for launch in March of 1996. 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. Major participants include the Smithsonian Astrophysical Observatory, the Millitech Corporation, Ball Aerospace, and the University of Cologne. which provides a spectrometer.

The Transition Region and Coronal Explorer (TRACE) Small Explorer initiated development in October 1994 and is scheduled for launch in late 1997. TRACE is a solar science mission that will explore the connections between he-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. Major participants include the Lockheed Palo Alto Research Laboratory and the Harvard-Smithsonian Center for Astrophysics.

The Wide-field Infrared Explorer (WIRE) Small Explorer also initiated development in October 1994. and is scheduled for launch in late 1998. 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. Major participants include Utah State University, Ball Aerospace, Cornell University. CalTech, and the Jet Propulsion Laboratory.

University Class

University-class Explorer (UNEX) missions *are* currently planned to help NASA achieve a higher future flight rate. UNEX missions will cost only a few million dollars each for definition, development, and operations. UNEX missions will be similar to the Student Explorer Demonstration Initiative (STEDI) missions (SNOE and TERRIER) which are under development.

MEASURES OF PERFORMANCE

Delta-class

XTE:

ship to KSC		Completed about one week early in May 1995.
Plan:	June 1995	
Accomplished:	May 1995	
Launch		Launch delayed by launch vehicle concerns.
Plan:	August 1995	
Accomplished	December 1995	

ACE:

Initiate ACE spacecraft subsystem I&T Plan: September 1995 Accomplished: October 1995	Started about one month later than planned no impact to critical path. Assembly of the spacecraft continues as subsystems are delivered.
Instrument deliveries complete Plan: December 1996	All instruments ready for physical integration with the spacecraft. On schedule.
Begin environmental tests Pian: February 1997	Following completion of integration. the spacecraft enters its series of electrical, magnetic, vibration. thermal/vacuum, and balance tests. On schedule.
ship to Ksc Plan: July 1997	Spacecraft system level testing successfully complete. Move to KSC for integration with Delta II launch vehicle. On schedule.

Medium-class

FUSE:

Mission CDR Pian: April 1996 Current: April 1996	Confirmation that the mission design is sound. On schedule.
Spacecraft CDR Plan: June 1996 Current: June 1996	Confirmation that design is of sufficient maturity and detail, and is compatible with established interfaces (thermal, structural, etc.). Design frozen prior to initiation of full-scale hardware fabrication. On schedule.
Start Spacecraft I&T Plan: June 1997	Begin to assemble and test major components. On schedule.

MidEx::

Step 2 Selections Plan: March 1996 Current: March 1996	Two missions selected for start of Phase B definition studies. On schedule.

Small-class

TRACE:

Start integration and test Plan: August **1996** Current: August **1996**	Begin to assemble major components onto the spacecraft. On schedule.
Ship to launch site Plan: September **1997**	Move to KSC for integration with the launch vehicle. On schedule.

WIRE:

Start integration and test **Plan:** October **1997**	Begin **to** assemble major components onto the spacecraft. On schedule.

ACCOMPLISHMENTS AND PLANS

The Delta-class **X-ray** *Timing* Explorer **(XTE)** was successfully launched in December **1995. XTE** uses three instruments to conduct timing studies of **x-ray** sources. **XTE** will create a comprehensive record of the source of **x-rays** which vary intensity over time, and **will** characterize those attributes. The XTE **will also** perform a study of compact **x-ray** emitting objects such **as** binary stellar systems. The XTE spacecraft and one of **its** instruments were developed in-house at **GSFC.** with the other two instruments provided **by** the Massachusetts Institute of Technology and the University of California - San Diego.

ACE spacecraft subsystem development is scheduled to advance sufficiently to allow the **start** of integration and test in summer **1996.** Instruments **are** scheduled for shipment to the spacecraft during the latter part of FY **1996** in support of launch **as** early **as** August **1997.**

Following successful completion of the preliminary design and non-advocate reviews, development of the restructured FUSE mission began in December **1995.** A Mission Crltical Design Review is scheduled for April **1996,** and the Spacecraft CDR **is** scheduled for June **1996.** Fabrication of the spacecraft and instruments **will** continue into FY **1997,** leading to integration and test activities in the summer of **1997.**

The first MIDEX Announcement of Opportunity was released in March **1995.** In Step One of the evaluation process, thirteen proposals were selected in September **1995** for further evaluation. Step **Two** proposals from these thirteen missions ***are*** now under evaluation. **Two** missions will be selected for Phase **B** definition studies, leading to the **start** of development in FY **1997.**

In the **SMEX** program, FAST and **SWAS** will **be** launched **as soon as** possible following the return to flight status of the Pegasus XL launch vehicle. TRACE and **WIRE** completed 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.

NASA intends to use the additional FY 1996 UNEX funds provided by Congress to fund the Cooperative Astrophysics and Technology Satellite (CATSAT) mission. This mission, which had been considered as a backup to the first two STEDI missions, will now become the first UNEX. Development of the CATSAT spacecraft and launch vehicle will proceed as quickly as possible. Subsequent UNEX missions are expected to be launched at 1-year intervals.

BASIS OF FY 1997 FUNDING REQUIREMENT

DISCOVERY DEVELOPMENT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Mars Pathfinder *	79,700	33,700	--
Near Earth Asteroid Rendezvous *	50,000	8.300	--
Lunar Prospector *	--	36,400	19,800
Future Missions	--	23.800	55.000
To	129.700	102,200	74,800

* Total Cost information is provided in the Special Issues section

PROGRAM GOALS

The Discovery program provides frequent access to space for small planetary missions that will perform high-quality scientific investigations. Emphasis will be placed on increased management of the missions by private investigators. The program is intended to accomplish these investigations while enhancing the U.S. return on its investment and *aiding* in the national goal to transfer technology to the private sector. It seeks to reduce total mission/life cycle costs and improve performance through the use of new technology and through control of design/development and operations costs. 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 launch within 3 years from *start* of development. The program also seeks to enhance public awareness of. and appreciation for, space exploration and to provide educational program opportunities.

STRATEGY FOR ACHIEVING GOALS

The current Discovery missions, Mars Pathfinder, *NEAR*. Lunar Prospector and Stardust respond to the need for low-cost planetary missions with short development schedules. 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 planetary science program in the future.

The Mars Pathfinder mission was approved as a FY 1994 new start 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 small science landers on the Martian surface. Pathfinder will carry three science instruments and a microrover funded under the Space Access and Technology program. The multispectral stereo Imager for Mars Pathfinder (IMP) will characterize the Martian surface morphology and geology at a 1-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 II launch vehicle. Communications will be via the Deep Space Network and mission operations will be supported by the Multi-mission Ground Systems Office (MGSO) at the JPL.

The Near Earth Asteroid Rendezvous (NEAR) mission was approved as a new start with the FY 1994 budget. This program was conducted as an in-house development at the Applied Physics Laboratory (APL) with many subcontracted subsystems. Tracking and navigation support is being provided by the 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 determine the shape of the asteroid, distinguish albedo from topographic variations, and measure surface morphology. NEAR was successfully launched on a Delta II launch vehicle on February 17.1996. The EROS launch opportunity required an accelerated development schedule for NEAR of only 27 months.

The Lunar Prospector mission was selected as the third Discovery mission in FY 1995 with mission management from the NASA Ames Research Center. Lockheed Martin will provide the launch, spacecraft. instruments, and operations. Tracking and communications support will be supplied by the Deep Space Network. The mission is designed to search for resources on the Moon, with special emphasis on the search for water in the shaded polar regions. In addition, the mission will provide accurate gravity and magnetic models of the Moon, supplement the surface data collected by the Galileo and Clementine missions and provide major additions to our understanding of the origin and evolution of the Earth. Moon, and Planets. The spacecraft carries four scientific instruments. The Gamma Ray Spectrometer (GRS) will provide an elemental analysis of the lunar surface by measuring several key elements: the Neutron Spectrometer (NS) will determine the abundance and distribution of hydrogen in the lunar surface which points to the possible water reservoir; the Alpha particle Spectrometer (APS) searches for gas release events and maps their distribution: and the Magnetometer and Electron Reflectometer (MAG/ER) provides a comprehensive lunar magnetics investigation. In addition. a Doppler gravity experiment (DGE) will be conducted using the spacecraft communications system to provide a map of the lunar gravity field. Launch will be on a Lockheed Launch Vehicle - 11 in October 1997. The launch window is ten-days long and repeats every month.

The Stardust mission was selected as the fourth Discovery mission in November 1995. The mission team has completed the Phase A analysis, and is beginning Phase B. The mission is designed to gather samples of dust from the comet Wild-2 and return the samples to Earth for detailed analysis. The mission will also gather and return samples of interstellar dust that the spacecraft

encounters during its trip through the Solar System to fly by the comet. Stardust will use a new material called aerogel to capture the dust samples. In addition to the aerogel collectors, the spacecraft will carry three additional scientific instruments. An optical camera will return images of the comet: the Cometary and Interstellar Dust Analyzer (CIDA) is provided by Germany to perform basic compositional analysis of the samples while in flight; and a dust flux monitor will be used to sense particle impacts on the spacecraft. Stardust will be launched on the Med-Ute expendable launch vehicle in February 1999 with return of the samples to Earth in January 2006.

PERFORMANCE MEASURES

Mars Pathfinder:	
Flight System Assembly and Test M e w man: April 1995 Accomplished: April 1995	M e w ensures that flight system hardware is ready to proceed into assembly and test phase.
Complete Instrument Deliveries Plan: September 1995 Accomplished: December 1995	Last instruments delivered to JPL for integration with spacecraft hardware!. Completed December 1995. No impact to launch date.
Flight qualification tests complete Plan: December 1995 Current: June 1996	Performance testing of major elements of Entry, Descent and Landing (EDL) subsystem (airbag, aeroshell, chute, etc.) to assure survivability of payload during Mars landing. Tests now scheduled to continue through June 1996. No impact to launch date.
Flight hardware deliveries Plan: January 1996 Accomplished: January 1996	Flight model spacecraft subsystems (aeroshell. chute. bags, microrover, etc.) fabrication and testing completed. Initiate system level integration.
Pre-ship Review (PSR) Plan: August 1996 Current: August 1996	Ensure spacecraft is ready for shipment to Kennedy Space Center (KSC) for integration with Delta II launch vehicle. Shipment to KSC planned for September.
Launch Plan: December 1996	Development complete. Initiate spacecraft checkout and mission operations.
Near Earth Asteroid Rendezvous:	
Critical Design Review (CDR) Plan: November 1994 Accomplished: 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 Plan: June-August 1995 Accomplished: June-August 1995	Flight model spacecraft subsystems and instruments completed. Begin system level integration and test phase.
Pre-ship Review (PSR) Plan: January 1996 Accomplished: December 1996	Ensure spacecraft is ready for shipment to Kennedy Space Center (KSC) for integration with the Delta II launch vehicle. Completed one month ahead of schedule.
Launch Plan: February 1996 Accomplished: February 1996	Development phase complete. Initiate spacecraft checkout/cruise operations.
Lunar Prospector Instrument Delivery for I&T Plan: October 1996	Flight model spacecraft subsystems and instruments completed. Begin system level integration and test phase.
Test Readiness Review Plan: November 1996	Flight System test Readiness Review ensures that the flight systems are prepared for environmental testing.
stardust System Requirements Review Plan: April 1996 Current: April 1996	Ensures mission requirements can be met with current technology and expected developments.
Technical Design Review Plan: October 1996	Review to assure readiness to proceed with detailed design and development.
Preliminary Design Review (PDR) Plan: October 1996	Review confirmed that proposed project baseline meets all program-level performance requirements and represents acceptable level of cost and technical risk
Critical Design Review Plan: June 1997	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.

ACCOMPLISHMENTS AND PLANS

Mars Pathfinder completed subsystem integration and test phase in December 1995 and is now in the initial portion of the system integration and test activity. All Entry, Descent, and Landing testing and simulations are on schedule. Flight Unit Rover was delivered to Assembly Test and Launch Operations (ATLO) in January 1996 and deliveries were completed in December 1995. The flight subsystems are undergoing integration into the launch configuration, and full system tests will proceed. Pathfinder has a long test period prior to the August Pre-ship review. Shipment to the Cape will occur in September, in preparation for a December 1996 launch.

The NEAR mission began its development phase in December 1993 with a preliminary design review in April 1994. NEAR completed its critical design review in November 1994. Fabrication of spacecraft and instrument subsystems was completed in May 1995 and system-level integration and test activities began in June and were completed in October 1995. The NEAR environmental testing was completed in November 1995, followed by spacecraft shipment to the KSC in December 1995. NEAR was launched February 17, 1996.

The Lunar Prospector was selected as the third Discovery mission in February 1995. Phase B activities were initiated in April 1995 and phase B design activities were completed in October 1995. A successful Technical Design Review was conducted at the end of Phase B. prior to initiating Phase C/D. Orders for procurement of major subsystems have been completed. Fabrication and integration of the scientific instruments is planned to occur in September 1996. Integration and test of the complete spacecraft is planned to be completed by May 1997. with shipment to the launch facility in September 1997. Launch is scheduled for October 1997 aboard a Lockheed Launch Vehicle 2.

The Stardust mission was selected as the fourth Discovery mission in November 1995. Phase A study activities were initiated in April 1995 and the Phase A was completed in October 1995. Phase B analysis activities have been initiated. A technical design review is scheduled for September 1996, prior to initiating Phase C/D.

Additional resources are requested in FY 1997 and beyond to initiate development of future Discovery missions. Announcements of Opportunity will be released on a regular basis. Emphasis will be placed on industry and university participation as well as scientific merit. Funding supports a planned launch rate of one per year beginning in FY 1999 aboard Med-Ute launch vehicles.

BASIS OF FY 1997 FUNDING REQUIREMENT

MARS SURVEYOR PROGRAM

	FY 1995	FY 1996	FY 1997
		(Thousands of dollars)	
Mars Global Surveyor *	58,000	58,200	9,400
Mars Surveyor 98 Orbiter and Lander *		52.300	77,500
Future Missions	1,400	1,400	3,100
To	59,400	111,900	90,000

* Total Cost information is provided in the Special Issues section

PROGRAM GOALS

Mars has been a primary focus due to its potential for previous biological activity and for comparative studies with Earth. The Mars Observer mission was launched in September 1992 and arrived at Mars in August 1993. Unfortunately, communications with the spacecraft were lost just prior to orbit insertion. NASA is currently seeking to regain the lost science from the Mars Observer mission with the Mars Surveyor program. This is a series of *small* missions designed to resume the detailed exploration of Mars.

STRATEGY FOR ACHIEVING GOALS

This program began in FY 1994 with the development of the Mars Global Surveyor. an orbiter which will obtain much of the data that would have been obtained from the 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* orbiters and landers which will make in-situ measurements of the Martian climate and soil composition. Technology developed by the Mars Pathfinder mission will be optimized to reduce lander mission costs and technical risk. *An* orbiter launch is planned in December 1998, a lander launch in January 1999. two launches in the February 2001 opportunity, and launches in the 2003 and 2005 opportunities.

PERFORMANCE MEASURES

Mars Global Surveyor

Program Confirmation Review plan: February 1995 Accomplished: February 1995	Confirms that overall budget/schedule baseline is adequate to proceed with mission development.
Spacecraft System Critical Design Review (CDR) Plan: May 1995 Accomplished 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.
Instrument Calibration and Test plan: December 1995 Current: May 1996	Instrument integration completed. Instruments operated under simulated flight conditions to validate/characterize performance against design specifications. Completion rescheduled to May 1996 without impact to launch.
Instrument deliveries Plan: February 1996 Current: May 1996	Instruments begin delivery to Lockheed Martin for integration with spacecraft prior to initiation of system level testing. Completion rescheduled to May 1996 without impact to launch date.
System Acceptance Review Plan: August 1996 Current: August 1996	Assure that flight hardware integration is complete and ready for final acceptance tests. On schedule.
Operational Readiness Review plan: October 1996 Current: August 1996	Formal review approving test results and recommending mission launch. Schedule accelerated to August 1996.
Launch Plan: November 1996	Development phase completed. Initiate spacecraft checkout and cruise operations. On schedule.

1998 Mars Surveyor Orbiter and Lander

Preliminary Design Review (PDR) Plan: March 1996 Current: March 1996	Review to be held the first week in March 1996 will confirm that the proposed project baseline meets all program-level performance requirements and represents acceptable levels of cost and technical risk.

Payload Confirmation Review Plan: April 1996 Current: April 1996	Confirms that tentatively selected payload can be accommodated within the spacecraft specifications. On schedule.
Spacecraft Systems Critical Design Review (CDR) Plan: January 1997	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. On schedule.

ACCOMPLISHMENTS AND PLANS

In FY 1995. MGS continued refurbishment of residual Mars Observer instrument spares. Detailed design activities supported the spacecraft PDR in October 1994 and CDR in May 1995. Hardware fabrication and assembly was conducted throughout the year to prepare for systems testing to begin in early FY 1996. The MGS will began instrument testing and calibration and will be delivered in May 1996. System level integration and testing will be conducted throughout the year, and a operational readiness review will take place in August in preparation for a November 1996 launch.

The follow-on Mars Surveyor missions. an orbiter and a lander, will be launched in December 1998 and January 1999, respectively. The selected payload for the orbiter include the Pressure Modulator Infrared Radiometer (PMIRR), a part of the Mars Observer payload, and a Color Imager. A Descent Imager and a comprehensive Volatiles and Climate payload have been provisionally selected for the lander. The lander will also accommodate a Russian LIDAR atmospheric instrument. Lockheed-Martin Aerospace, Denver, was selected through a competitive process as the spacecraft development contractor. The payload confirmation review will be conducted in April 1996. Preliminary Design review is scheduled for March 1996, with the Critical Design review scheduled for January 1997.

BASIS OF FY 1997 FUNDING REQUIREMENT

LENNIUM PROGRAM

	FY 1995	FY 1996	FY 1997
		(Thousands of dollars)	
New millennium spacecraft	(10,500)	30,000	21,500

PROGRAM GOALS

New Millennium is a partnership between programs for Space Science and Space Access and Technology. Past history has shown the development of new technology has enabled bolder scientific investigations and has significantly enhanced the data return from all Space Science missions. In this vein, the New Millennium program has been established to precipitate a revolution in the design, development and implementation of science spacecraft and instruments for the next century. The primary objectives of the program are to provide for the infusion of new technology through the focused development of key breakthrough technologies, and flight validation of their performance. Rapid development of spacecraft and instruments utilizing key technologies at a systems level will allow for micro spacecraft and micro instruments with lower mass and equivalent performance. Intelligent flight systems will be developed where navigation, data gathering and health monitoring functions can be fused with the spacecraft. The resulting microspacecraft will allow for increased flight rates on smaller, less costly launch vehicles. Intelligent night systems and shorter flight times will translate into smaller operations staff, allowing for increased scientific capabilities of the missions. increased technological capability, and reduced life cycle costs.

With this new ideology in spacecraft development, the New Millennium program will bypass the current process of incorporating new technology into the NASA flight programs at a systems level. The program emphasizes the strategic alliance between Space Science and its primary technology provider Space Access and Technology. This enhanced partnership allows Space Science funds to benefit from technology programs both internal and external to the Agency. The result of this new systems approach is a program which integrates the sources of technology development to emphasize the enabling technologies needed to support our future science missions.

STRATEGY FOR ACHIEVING GOALS

The program will work with the science community to highlight key scientific challenges to be addressed in the new millennium. Key capabilities to meet these challenges, and the associated emerging technologies which address these capabilities will be identified. Those technologies which contribute most significantly to ultimately achieving program goals will be selected, aggressively pursued and flight demonstrated. Current plans reflect technology demonstration missions occurring at a rate of one or more per year, beginning as early as 1998. Although, the primary purpose of these missions will be to validate the high priority technologies needed to enable future science missions. the demonstration nights will also, to the maximum extent possible. exploit scientific targets of opportunity.

In implementing the strategy. NASA will place a strong emphasis on innovative management approaches assuring synergistic teaming with industry. academia, and other government agencies. The Jet Propulsion Laboratory will manage program implementation.

PERFORMANCE MEASURES

Implementation Plan Drafted Plan: December 1994 Accomplished: December 1994	Proposed implementation process identified (preliminary). Completed on schedule.
Technology Workshop Plan: February 1995 Accomplished: March 1995	Review proposed implementation process with Industry, academia, other government agencies: Broad identification of emerging technologies of interest.
Implementation Plan (Final) plan: February 1995 Accomplished March 1995	Implementation process finalized and approved.
Preliminary Mission Set Provided. Evaluated, Downselected Plan: April 1995 Accomplished: March 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 Plan: mid-1995 Accomplished: May 1995	Approximately four mission sets evaluated in detail: Downselect to one or two high-priority mission sets.
Select Partners Plan: mid-1995 Accomplished: July 1995	Identify partners from industry, academia, other government agencies to form Integrated Product Development (IPD) teams.
Deep Space (DS) Mission I Interim Design Review Plan: December 1995 Accomplished: December 1995	Peer review of system and subsystems. architecture and preliminary designs.

DS II Design Review **Plan:** Current:	 February 1996 February 1996	Initial system level design and technologies identified.
DS Mission I **plan:** Current:	 April 1996 April1996	Peer **review** of complete system and subsystem designs, ready for Detailed Design Concurrence fabrication.
DS Mission I Implementation **Plan:** Current:	 May 1996 May 1996	Award contract for fabrication. assembly, test and operations of Contract DS I.
Select technology partners **plan:** Current:	 August 1996 August 1996	Refresh integrated product development teams with new industrlal teams with new industrial partners who *are* developing revolutionary technologies.
DS 11 Project Review #2 plan.	 March 1997	Detailed system level design and technologies identified.
DSI Start of ATLO Plan:	 June 1997	**Start** assembly, test, and launch operations of DS1.
DSII Ship to STV Plan:	 December 1997	Ship micro-probe to solar thermal vacuum chamber.
Launch DS I Plan:	 July 1998	First **New** Millennium technology demonstration flight. On schedule.
Launch **DS** 11 Plan:	 January 1999	Piggyback on Mars 98 Lander

ACCOMPLISHMENTS AND PLANS

The prlmary emphasis during 1995 **has** been the formation of the Integrated Development Teams (IPDTs) and establishing industrial partnerships. To date, **thirty-one** different organizations, including several *small* businesses and ten universities **are** working with the **New** Millennium pmgram to develop technology roadmaps and those technologies needed for the **2** 1st century science exploration. In addition, **an** industrial partner, Spectrum Astro, has been selected to design and begin implementation of the first deep space mission. The emphasis in calendar year 1996 will be on insuring that the technologies needed for the first

mission are on schedule and *can* meet the program goals. Hardware and software procurements. the hardware fabrication and subsystem testing for the **1998** launch will **be** completed. The design for Deep Space Mission 11 will be completed and an industrial partner to work the early mission design for Earth orbiting one will **be** selected. In addition, a conceptual design of Deep Space Three. the interferometer spacecraft, will be completed. The principle activities in **FY 1997** will include the completion of the fabrication and assembly of the spacecraft for the Deep Space I mission. In addition, the integration and test of the new technologies associated **with the** first **New** Millennium launch **will be** completed. The **majority** of early analysis and test for Deep Space 11 will **be** completed and fabrication of flight **hardware will begin.**

BASIS OF FY 1997 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
HST operations and servicing	236.700	182.700	193,400
HST data analysis	37.700	43.500	43,100
AXAF mission operations and data analysis	18,900	40,400	41,300
GGS mission operations and data analysis	8.800	26,500	25,500
COSTR mission operations and data analysis	11,700	31,900	28,400
GRO mission operations and data analysis	22,500	18,000	16,300
Galileo operations	70,700	71,700	66,400
NEAR operations	--	4.900	8,500
Mars surveyor operations	--	--	16.400
Mars pathfinder operations	--	--	9,600
Lunar prospector operations	--	--	800
Planetary flight support	46.500	49,400	42,900
Other mission operations and data analysis	91,100	94,800	99,800
To	544,600	563,800	592,400

PROGRAM GOALS

The goal of the Mission Operations and Data Analysis (MO&DA) program is to maximize the scientific return from NASA's investment in spacecraft and other data collection sources. The MO&DA effort is fundamental to achieving the goals of the Office of Space Science (OSS) program because it funds the operations of the data collecting hardware and the data analysis that produces scientific discoveries. Funding supports satellite operations during the performance of the core missions, extended operations of selected spacecraft. and 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.

The MO&DA program is working to dramatically reduce 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 are 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 replacement of spacecraft subsystems and scientific instruments about every three years. Ongoing modification and upkeep of system ground operations are also performed.

Pre-launch operations funding for the Advanced X-ray Astrophysics Facility (AXAF) program supports the development of a ground control system and a science operations center, and preparation for flight system operation. The AXAF Science Center (ASC) in Boston, 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. NASA has recently decided that AXAF operations will be conducted from a control center at the ASC, rather than at MSFC. This decision was made pursuant to the Zero Base Review team recommendation that AXAF be managed by an Institute.

Currently. six operational astrophysics missions (besides HST) and ten operational space physics missions are supported. Astrophysics missions include the X-ray Timing Explorer (XTE, 1995), the Extreme Ultraviolet Explorer (EUVE, 1992).the Compton Gamma-Ray Observatory (CGRO, 1991), 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 SOHO (1995), Wind (1994), Geotail (1992), SAMPEX (1992).Yohkoh (1991).Ulysses (1990), Voyager 1 and 2 (1977).Pioneer 10 (1972), and the Interplanetary Monitoring Platform (IMP-8, 1973).

XTE uses three instruments to conduct timing studies of x-ray sources. EUVE is studying the sky at wavelengths once believed to be completely absorbed by the thin gas between the stars. The CGRO measures gamma-rays, providing unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars. and supernova, as well as on the nature of the mysterious cosmic gamma-ray bursts. 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. SOHO will study the solar interior by measuring oscillations of the solar surface. SOHO will also investigate the hot outer atmosphere of the Sun that generates the variable solar wind and W and x-ray emissions affecting the Earth's upper atmosphere, the geospace environment, and the heliosphere. 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. SAMPEX is measuring the composition of solar energetic particles, anomalous cosmic rays, and galactic cosmic rays. 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 Ploneer 10 are continuing to probe the outer hellosphere and look for the hellospheric boundary with interstellar space as they travel beyond the planets. IMP-8 performs near-continuous studies of the interplanetary environment for orbital periods comparable to several rotations of the active solar regions.

The Planetary Flight Support line maintains the Multi-mission Ground Systems Office (MGSO) at JPL. This program provides ground system hardware, software, and mission support for all planetary programs. Planetary flight support activities are those associated with the design and development of multi-mission ground operation systems for deep space and high-Earth orbiting spacecraft to support mission control, tracking. telemetry, and command functions utilizing the Deep Space Network (DSN) for all supported spacecraft. At present, MGSO supports ongoing mission operations for Voyager, Ulysses, and Gallleo. The program also supports the development of generic multi-mission ground system upgrades such as the Advanced Multi-mission Operations System (AMMOS). This new capability is designed to significantly improve our ability to monitor spacecraft systems, resulting in reduced workforce levels and increased operations efficiencies for *Cassini* and future planetary missions. New missions such as the Mars Pathfinder and Mars Surveyor programs work closely with the Planetary Flight Support Office, resulting in ground systems developed at minimum costs, in reduced time, with greater capabilities, and designed to operate at reduced overall mission operations costs.

MEASURES OF PERFORMANCE

HST:

Second Servicing Mission Critical Design Review Plan: July 1995 Accomplished: July 1995	Validated the overall content and procedure for the 1997 second servicing mission.
Cargo Integration Review for the Second Servicing Mission Plan: March 1996 Current: March 1996	Completes coordination of HST flight hardware and carriers destined for the space shuttle cargo bay with JSC payload integration. On schedule.
Advanced Camera System Critical Design Review Plan: April 1996 Current: April 1996	Validate design maturity in preparation for system fabrication. On schedule.
Delivery of NICMOS and STIS to GSFC Plan: August 1996 Current: August 1996	Instrument development activities completed: instruments shipped to GSFC to begin final integration and testing. On schedule.

2nd Servicing Mission Plan: February 1997	Replace Faint Object Spectrometer (FOS) and Goddard High Resolution Spectrometer (GHRS) with STIS, add NICMOS instrument, other replacement hardware as required. On schedule.
Advanced Camera System Alignment Completed Plan: September 1997	Complete optical alignment in preparation for final integration and test, prior to shipment to GSFC. On schedule.

AXAF:

On-Line System Critical Design Review Plan: March 1995 Accomplished: March 1995	Major review validated hardware and software systems which will support primary aspects of AXAF operations. including data acquisition and distribution to the AXAF Science Center, spacecraft command/telemetry, etc.
Off-Line System Critical Design Review Plan. September 1995 Accomplished: September 1995	Validated design maturity of the software system which will be used to process spacecraft commands generated by mission planners and the flight operations team.
Off-line release 1 Plan: January 1996 Accomplished January 1996 On-line Release 1 Plan: February 1996 Current: February 1996	First major deliveries of ground system hardware and software for integrated systems testing. Off-line release delivered on schedule: On-line release expected on schedule.
AXAF Science Center End-to End CDR Plan: January 1997	Validate design maturity in preparation for ASC system development. On schedule.
Ground systems ready to support Integration and Test Plan: July 1997	Able to proceed with spacecraft integration and test activities.

Galileo:

Galileo probe release and orbit maneuver Plan: July 1995 Accomplished: 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 Plan: December 1995 Accomplished December 1995	Maneuver the orbiter into orbit around Jupiter. Initiation of prime mission operations.
Return Robe Data Plan: March 1996 current: May 1996	All probe data sent to and stored on the orbiter transmitted to Earth. Critical element of overall mission objectives. To be completed May 1996.
Return Io and Jupiter Encounter Data and its moon Io. man: July 1996 Current: July 1996	Transmit to Earth, science data and imagery from encounters with Jupiter.
Ganymede Encounter Plan/Current: July 1996 Ganymede Encounter Plan/Current: September 1996 Callisto Encounter Plan/Current: November 1996 Europa Encounter Plan/Current: December 1996	Transmit all science data and imagery from the Europa., Ganymede and Callisto encounters in 1996 to Earth. *All* encounters on schedule.
<u>Near Earth Asteroid Rendezvous:</u>	
Launch Plan: February 1996 Accomplished February 1996	To rendezvous with the asteroid EROS, *NEAR* had to launch in February 1996. Another launch opportunity occurs 11 months later to a different near Earth asteroid.
<u>Mars Global Surveyor:</u>	
Launch Plan: November 1996 Current: November 1996	Launch window for rendezvous with Mars in 1997. for start of 2 year mapping, 3 year communications relay mission.
Mars orbit insertion man: September 1997 Current: September 1997	Bum to insert into Mars capture orbit.

Mars Pathfinder:

Launch Plan. December 1996 Current: December 1996	Launch window for Mats encounter and landing in July 1997.
Mars Landing Plan. July 1997 Current: July 1997	Lander lands on Martian surface, transmits engineerlng and science data back to Earth.

Planetary Flight Support:

First Cassini ITL Build Plan: April 1995 Accomplished: 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 Plan: September 1995 Accomplished: September 1995	Complete development and testing of modification to the multi-mission ground system to support Mars Pathfinder mission.
Galileo Phase II Development Plan: November 1995 Accomplished: 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 Plan: January 1996 Accomplished: 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 Pre-Launch Operations support Plan: August 1996 Current: 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. On schedule.

ACCOMPLISHMEN AND PLANS

Science output and education

NASA's Space Science spacecraft continue to generate a stream of scientific discoveries. Many of these findings are of broad interest to the general public. as witnessed by widespread media coverage. NASA is also finding ways to partner with the education community in order to strengthen science, technology. and mathematics education.

The first Hubble Space Telescope (HST) servicing mission in December 1993was a tremendous success. The observatory is now fulfilling the promises NASA made for it, generating an ongoing stream of major scientific discoveries. HST is creating great public interest as measured by frequent major news and television reports. HST images are also being distributed to school children nationwide through NASA's national "Teacher Resource Laboratory" system. In a comparative review of eleven astrophysics MO&DA programs, an external panel of senior scientists judged HST to have the highest science merit, based on total science as well as on a science-per-dollar basis.

Ulysses has completed its historic mission over the poles of the Sun during a period of minimum solar activity, and has discovered global differences in the fast and slow solar wind from the equator to the poles. Ulysses also determined that interstellar dust does reach into the inner solar system, and that the velocity and direction of interstellar dust compares well with that of interstellar helium. Another major discovery is that the magnitude of the radial component of the magnetic field is uniform in the north and south polar regions and in the equatorial region. and that the solar wind is expanding from the pole to the equator.

In 1983-1984 and again in 1992-1993, Voyagers 1 and 2 detected strong radio emissions bursts. A strong case can now be made that these bursts were triggered by the interaction of an interplanetary shock with one of the outer boundaries of the heliosphere. Voyagers 1 and 2, and Ploneer 10 are all monitoring anomalous cosmic ray fluxes which are particularly important to understand the structure of the heliosphere. Exploration of the hellosphere by these spacecraft, along with the Ulysses and the Earth-anchored IMP-8 constitute the largest scale in-situ astrophysical investigation that can be carried by the spacecraft in the 20th and 21st Century. It has taken more than two decades for the spacecraft to reach these positions.

Nineteen years of IMP-8 mass flux has been compared against solar neutrino fluxes. Results show that the solar wind mass flux and neutrino flux vary together, and may indicate the neutrino property's ability to interact with magnetic fields in the solar convection zone.

SAMPEX is using the Earth's magnetic field itself as a giant magnet spectrometer to make definitive measurements of the charge states of the Anomalous Component of cosmic rays and of solar energetic particles. SAMPEX has found that magnetospheric electrons are globally accelerated in association with the impact of high speed solar wind streams. Also. in collaboration with Voyager, Ulysses, and Ploneer spacecraft. SAMPEX found that the intensity of Anomalous Cosmic Ray Oxygen ions increased with heliolatitude durlng its 1993 approach to solar minimum; this confirms predictions of one class of particle transport theories which include particle draft.

Geotail discovered that atmospheric oxygen ions far out (900,000 miles) in the Earth's magnetic tail are accelerated to extremely high speeds, in excess of a million miles an hour. The Geotail spacecraft has established the importance of flux ropes in the Earth's magnetotail. This will displace the long-accepted picture of plasmoids as an important phenomenon in the magnetotail. Geotail also detected two different types of "breathing" of the Earth's magnetotail, the 'windsock effect' and 'magnetospheric substorms'. The "breathing" phenomenon is currently being investigated.

Yohkoh has revealed that the Sun appears 100 times dimmer at x-ray wavelengths today than in 1991. It has also discovered that the hottest part of flares are frequently located at the top of high arch structures on the solar surface.

The Wind spacecraft found itself immersed in a magnetic cloud for 30 hours on October 1995, and provided an unusual level of coordination *among* different spacecraft in the ISTP program. Wind is also conducting detailed studies of the interaction of the moon with the solar wind, and has been used in conjunction with Ulysses to triangulate type III solar bursts so that the global magnetic field in the interplanetmy medium can be mapped. Wind has resolved the isotopic components of the solar and anomalous cosmic rays.

Operations for Gallleo began in October 1989 at the start of the spacecraft's six-year journey to Jupiter. The spacecraft passed by Earth in December 1992 for the second and last time as it departed the inner solar system. Since launch, the spacecraft has 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 satellite 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 from the collision of comet Shoemaker-Levy with Jupiter was completed February 1995.

Failure to deploy the High Gain Antenna (HGA) has required a rebaselining of the mission for use of the Low Gain Antenna (LGA) *only.* Changes in mission design and DSN coverage required to support the new mission requirements. New flight and ground software were developed to achieve the majority of Galileo's objectives using only its LGA. This is being achieved at a cost lower than what was *originally* estimated for the primary use of the LGA.

Galileo's atmospheric probe was released in July 1995 and successfully entered Jupiter's atmosphere shortly before Galileo was successfully inserted into Jupiter orbit December 7, 1995. The Orbiter has begun its 23 month study of the Jovian system, and will orbit the giant planet 11 times. During 1996, Galileo will complete the return of the probe data as well as new science and images from Jupiter and encounters with the four Galilean satellites. Io, Ganymede, Europa and Callisto.

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 began June 1995. The NEAR spacecraft was launched from Cape Canaveral *Air* Station on a Delta II on February 17, 1996. It will orbit the Sun to two astronomical units and fire its bipropellant system at aphelion in March 1997. In January 1998, it will swing by the Earth to achieve the proper inclination to the elliptic plane to rendezvous with EROS. In January 1999, NEAR will come within 1000 km of EROS and fire 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.

The Mars Global Surveyor (MGS) mission began the design/development phase in February 1994. when NASA gave JPL the authority to proceed. The System Requirements Review was held in April 1994, and the Critical Design Review was held in May 1995. Subsystem integration began in the summer of 1995, and integrated tests began in October 1995. Instrument deliveries to the spacecraft contractor will be complete by May 1996. MGS will launch from Cape Canaveral Air Station aboard a Delta II 7925 in November 1996. After a 10 month cruise, ending in September 1997, MGS will use a combination of thruster firings and aerobraking for a period of four months to reach a nearly circular mapping orbit. Mapping operations are scheduled to begin in March 1998. MGS will maintain the low circular orbit for two years for the prime mapping portion of the mission. After this period, MGS will raise its orbit to the altitude required for planetary quarantine, and continue operations as a communications relay orbiter for other U.S. and international landed missions.

The Mars Pathfinder mlssion underwent a formal Design, Implementation and Cost Review in July 1993, and Flight System Preliminary Design Reviews were completed in December of that year. The critical Design Review was held in September 1994, and Assembly and Test (ATLO) began in June 1995. The spacecraft will launch from Cape Canaveral Air Station in December 1996, and enter the Mars atmosphere in July of 1997. The lander will be cushioned by large airbags, which will protect the tetrahedral lander, the microrover. and the scientific instruments. Once at rest on the planet's surface. the bags will deflate and retract, the lander will open like petals of a flower, and the spacecraft will transmit the entry, descent, and landing data, including a panoramic image of the landing site to the Earth. The rover will then roll off its petal, and begin engineering design tests, as well as compositional tests of the mars soil. The nominal life of the mission is 7 days for the rover, and 30 days for the lander; however, both could last longer.

The Space Science program continues to make progress in lowering MO&DA costs while preserving the science return from operating missions. As a result, NASA expects to be able to support the increasing number of operational spacecraft within an essentially flat MO&DA budget proffle. In total, NASA expects to be operating 25 spacecraft at the end of FY 1997. compared to 13 at the beginning of FY 1995. Missions expected to begin operations in FY 1996-1997 include Polar (2/96), Cluster (5/96), the Russian Spectrum-X Gamma (SXG, 12/96). NEAR (2/96), Mars Global Surveyor (11/96), Mars Pathfinder (12/96), the Argentine Satelite de Aplicaciones Cientificas-B (SAC-B. TBD), the High Energy Transient Experiment (HETE, TBD), the Submillimeter Wave Astronomy Satellite (SWAS, TBD), and the Fast Auroral Snapshot (FAST, TBD). The last four spacecraft are all awaiting the return to flight of the Pegasus launch vehicle.

The Space Physics mission set has undergone an extensive review by an outside panel which made 52 recommendations for improvement in operational efficiency. Responses to each recommendation have been generated, and changes to the program are being implemented. Several investigations were terminated or severely reduced as a result of the review. Roneer 11 operations were terminated in September 1995 due to the low level of power remaining on the spacecraft, which limited its science output.

During the past year, science instrument operations for EUVE have been transformed from three-shift, around-the-clock staffing to single-shift staffing. This transition has been accomplished without loss of science, and without endangering the orbiting instruments. At the present time, the EUVE team is testing a transition to zero-shift instrument operations.

The U.S. role on the International Ultraviolet Explorer (IUE) has entered the two-year completion phase. Since October 1995, all science observations are being executed by the ESA operations team at Villafranca, Spain, while NASA continues computer and spaced state-of-health operations. Based on recommendations from recent comparative science reviews of Astrophysics missions, this NASA participation in IUE is planned to end at the end of FY 1996. During FY 1997, the U.S. IUE effort will be concentrated on completion of the final science data archive. Preparation of the relevant documentation, including notice of intent to terminate U.S. operations and an export license. will be initiated in time to comply with the IUE-specific requirement for 6 months' notice of intent to terminate.

Planning for the second HST servicing mission in 1997 is ongoing. Integration and test activities for the Space Telescope Imaging Spectrograph (STIS) and the Near Infrared Camera/Multi-Object Spectrometer (NICMOS) are continuing in support of an August 1996 delivery to Goddard for final integration and testing.

The AXAF ground system on-line and off-line systems Critical Design Reviews were conducted in March 1995 and September 1995, as previously planned. The first major deliveries of ground hardware and software for integrated systems testing are expected early in CY 1996.

In the past year, significant progress has been achieved in commercializing technologies derived from HST. The Charged Coupled Device (CCD) technology is now successfully in clinical use with a new generation of breast biopsy machines. Testing at the Electric Power Institute has proven the efficacy of the Multi Anode Microchannel Array (MAMA) detectors for use in high voltage power line inspection. A recently completed marketing study has established the cost and performance goals for commercializing this technology. Finally, the HST program is forging a new partnership with the semiconductor industry to develop the next generation of microlithographic equipment using ultra-precision optics. A national partnership agreement is in review and industrial funding ($360,000) is already committed. Success in this effort will reduce risk in future NASA science missions and enhance the International competitiveness of the U.S. semiconductor and lithography industry.

BASIS OF FY 1997 FUNDING REQUIREMENT

SUPPORTING RESEARCH AND TECHNOLOGY

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Space physics supporting research and technology	35.700	35,700	38,500
Astrophysics supporting research and technology	39.700	39,700	44,400
Planetary supporting research and technology	108,400	109,100	108,300
SIRTF ATD	--	10,000	24,900
TIMED	--	15,000	15,000
Magnetospheric imager ATD	--	2,900	--
New millennium ATD	10,500	--	--
Information systems	26.100	25,900	24.900
High performance computing & communications	--	600	3,200
To	220.400	238.900	259.200

PROGRAM GOALS

The goals of the Research and Analysis (R&A) program in the Space Science program 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, space physics, and solar system exploration research for future flight missions. the program also develops and promotes United States scientific and technological expertise.

The information systems program provides the state-of-the-art data management, networking. and computing environment in support of all of the science research objectives. Information systems and related technologies are essential to NASA's Scientific Enterprise. The High Performance Computing and Communications (HPCC) effort is aimed at accelerating the development, application and transfer of High Performance computing technologies to meet the engineerlng and science needs of the U.S. space science community.

STRATEGY FOR ACHIEVING GOALS

The R&A program carries out its objectives by providing grants to universities, nonprofit and industrlal research institutions, and funds to scientists at NASA Centers and other government agencies. Several hundred grants are awarded each year after a rigorous peer review process: only about one out of four proposals is accepted for funding. 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. Many of these grants fund new types of detectors and scientific instruments which are flown aboard sounding rockets or balloons, and may later be adapted for flight aboard future free-flying spacecraft. These suborbital payloads, besides performing low-cost science and training future scientists, thus enable more capable, less costly future spacecraft. Other grants fund purely theoretical studies which help direct future experimental investigations.

Funding also supports activities which develop new free-flying mission concepts and ensure that the technology for a specific 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 NASA to better utilize advanced technologies in future missions.

The information systems program will provide access to high performance networking, computing and data resources, and an interactive analysis environment with efficient access to data, mathematical processing 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 an Intemet-based computer networking Service providing access to flight program databases, data processing systems, and other applications for scientific collaboration. 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. analysis and visualization techniques to improve scientists' productivity, as well as to provide the transfer of new information technology 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.

The HPCC work within Space Science supports two of the four HPCC projects. Remote Exploration and Experimentation (REE) is confronting the challenge of developing low-power. fault-tolerant, high-performance, scaleable computing technology for a new generation of microspacecraft for planetary exploration. The REE project, led by the Jet Propulsion Laboratory, will work in close partnership with industry, academia and government. Teams will be formed to create a two-way pather for the infusion of new, off-

the-shelf component technology from industry to NASA and for the transfer of REE-developed technology (fault-tolerance. packaging and miniaturization, architectures, etc.) back into the private sector for commercial use. Information Infrastructure Technology and Application (IITA) focuses on providing the technology base and applications to accelerate the implementation of the National Information Intrastructure.

MEASURES OF PERFORMANCE

Technology development of advanced x- and gamma ray detectors **(ongoing)**	Significant progress was made in FY **1995.** including advances in room-temperature hard **x-ray** devices. Tests of a prototype detector on **high** altitude balloon flights provided critical assessment of the background levels **likely** to be experienced in low Earth orbit. **A** flight test of an advanced **x-ray** calorimeter device **is** planned for FY **1996. Work on** enhancing the ***key*** characteristics of the above detectors (spectral resolution, **imaging** capability, and sensitivity) will **be** continued in FY **1997 as** will development of innovative optical approaches for imaging in the hard ***x-ray*** regime.
Technology development of advanced infrared detectors **(ongoing)**	Continued and significant progress was made in the development, characterization and refinement of infrared detectors suitable for low-background (astronomy) applications. A primary motivation for supporting the successful development of these large-format **array** detectors and associated electronics **is** the requirement for low-noise detectors with high quantum efficiency for use aboard **SIRTF** -- the preeminent infrared observatory of the next decade. However, it **is** envisioned **that** such detectors will greatly benefit ground-based telescopes of even modest ***size*** **as** well **as** future planetary exploration missions.
Technology development of advanced submillimeter detectors (ongoing)	Significant milestones continue to **be** met and surpassed in the continuing development of bolometer and heterodyne submillimeter-wave detectors. The innovative and lightweight "spider-web" bolometer technology pioneered **by** ***Andrew*** Lange (CalTech) features a large effective capture area for far-infrared radiation, while displaying a very *small* cross-section to cosmic ray **hits.** The scientific performance of these bolometers, and their mechanical stability, will **soon** be tested **aboard** suborbital balloon and sounding rocket payloads.
Technology development of **advanced** Ultraviolet **(U/V)** detector systems **(ongoing)**	Major new developments in delay-line microchannel plate detector electronics and anode fabrication were achieved in FY **1994. This** technology was used to support replacement of defective detectors on the SOHO mission. Completion of a **3 year** study **is** 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)	Define a multi-faceted effort to study the detailed Interaction of solar magnetic fields and the associated flow of plasmas that lead to the variability of the Sun.
Theoretical studies of the Heliosphere (ongoing)	Continued science definition, new technology development and instrument design for a close solar flyby mission to study how the corona is heated and the solar wind is accelerated.
Theoretical studies of the Magnetosphere (ongoing)	Study of physical phenomena in the mesosphere/thermosphere/ionosphere system 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 due to variations in solar emissions. Fly rocket experiments to acquire necessary data.
SOFIA:	
Non-Advocate M e w : Plan: February 1995 Accomplished: February 1995	Confirmed that the program is ready to proceed Into development. 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.
SIRTF:	
Phase A studies completed Plan: September 1996 Current: September 1996	JPL In-house studies of alternative mission deslgns reviewed for relative technical merits (complexity, feasibility, etc.) cost and schedule requirements.
Complete Spacecraft Request for Proposal (RFP) Plan: September 1996 Current: September 1996	Documentation to support industry proposals for spacecraft development contract ready for release, Release contingent upon new start approval in FY 1997.

	FY 1995 Actual	FY 1996 Estimate	FY 1997 Estimate
NSSDC accesses			
World Wide Web Homepage visits:	26,000/day	*40,000/day	50,000/day
Data Archive & Distribution Services (NDADS) requests:	18,000	30,000	40.000
*WWW Homepage replaced NODIS			
NSI			
Nodes:	230	240	240
principle Investigator Users:	2100	2300	2300

Operational Internet network connection to Russia	Space Bridge Project greatly enhances communication and collaboration with Russian colleagues for all science programs. Video conference and other advanced multimedia applications are being supported.
Collaboration with USAID	Networking technology transfer to broaden Internet access to Africa.
Outreach	Supported 'Live from Antarctica" and 'Live from Stratosphere" outreach effort.
Phase out of NODIS	NSSDC On-Line Data and Information Services (NODIS) replaced by WWW Homepage.
Integrate ISTP data to NDADS	Make data available to Space Physics scientists in a timely manner.
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 planetaxy 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 Plan: September 1996 Current: 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 Plan: September 1996 Current: 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 Plan: September 1996 Current: 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 Plan: September 1996 Current: 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.
Detect and characterize individual interstellar grains in meteorites and IDPs (Ongoing)	A variety of Interstellar grains have been detected in meteorites and interplanetary dust particles that have been shown to have been formed in novae, supernovae and red giant stars. New microanalytic techniques allow Investigators to characterize the chemical composition of individual grains and to better understand the origin of the matter making up our planetary system.

Use isotopic traces of extinct radionuclides to constrain the timescales for the formation of planets **(Ongoing)**	A variety of short-lived radioactive elements are known to have been present in the early solar nebula. By searching for the isotopically distinct daughter products of a number of these elements and comparing their abundancies with stable, chemically similar elements, it is possible to constrain the sequence of processing events that led to the formation of individual planetessimals and to develop an absolute chronology for the evolution of the planetary system.
Identify the changes to specific types of planetary materials caused by the space and planetmy environments **(Ongoing)**	A wide variety of meteorite types, including meteorites from the Moon and Mars, are available for laboratory analysis. A basic understanding of the effects of the space environment and weather of the planets on the spectral properties of the meteorite samples is needed before these properties can be linked to spacecraft remote sensing observations of planets.
Complete a search for additional millisecond pulsars and monitor the planetmy system discovered around the neutron star PSR1257+12 **(Ongoing)**	Observatories using the Aricibo and Effelsburg radio telescopes are underway to find and catalog a large number of millisecond pulsars that *can* then be monitored for gravitational perturbations due to the presence of a planetary system and to monitor the evolution of the planetary system around PSR1257+12 due to mutual gravitational interactions to accurately determine the masses and orbital elements of the planetaxy system.
Initiate a study of the chemistry and structure of protostellar systems **(Ongoing)**	A very large number of individual investigators are working to unravel the complex chemical and physical evolution of collapsing protostellar systems for comparison with laboratory studies of meteorites and cosmic dust and for comparison with observations of comets and modem protoplanetaxy nebulae.
Continue long-term astrometric searches for evolved planetmy 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 planetaxy systems such as ours even around nearby stars.

Formulate the Solar System Exploration Strategic Plan Plan: Early 1997	The Solar System Exploration Subcommittee and the Science Working Groups are examining the fundamentals of Planetary Exploration and are reformulating the Plan Architecture. The new plan includes: rigorous scientificjustification; sequences of specific investigations and measurements; mission proposed to accomplish them: and outreach approach.
Continue development and validation of high priority technologies Ongoing	Solar Electric Propulsion needs to be validated for high energy planetmy missions; Acquisition and Analysis of samples from planetary surfaces and atmospheres must be developed for future in depth studies of the solar system; Utilization of local resources is the key to long term self sufficiency of the exploration program.
Formulate the Roadmap for the Exploration of Neighboring Planetary Systems Plan: Early 1996 Current: Early 1996	A dedicated team has been established, drawing on the broadest set of national and international expertise, to define a viable approach towards the imaging of Extrasolar planelmy systems in the next century.

Phase A/B Study Schedule

Pluto Flyby:	Pre-phase A study and technology development in progress FY 1997 - planned phase A (conceptual design) FY 1998 - planned phase B (definition study)
Rosetta/Champollion:	Pre-phase A study in progress (program formulation/mission needs) FY 1996/97 - planned phase A (conceptual design study) FY 1998 - planned phase B (definition study)

ACCOMPLISHMENTS AND PLANS

The R&A program continued to provide exciting scientific discoveries in 1995. A series of balloon-based observations of the cosmic microwave background anisotropies continued to yield impressive results. These observations are being conducted at sensitivities equal to or exceeding those associated with the historic Cosmic Background Explorer (COBE) satellite in 1989-1993, but on smaller angular scales. These scales are more physically important, inasmuch as they provide insight into the physics associated with the formation of structure in the early Universe corresponding to the largest structures we observe today.

Significant progress continued in the development and testing of innovative new x- and gamma-ray detectors. Tests of a prototype detector on high altitude balloon flights provided critical assessment of the background levels likely to be experienced in low Earth

orbit. Balloon-borne payloads flown from Australia also conducted high spectral/spatial resolution measurements of the sources in the Galactic Center region of our Milky Way galaxy as well as the active nuclei of other galaxies.

In the field of coherent detector development, various programs are moving closer to the "Holy Grail" of submillimeter heterodyne receivers -- performances approaching a few times the quantum limit at frequencies approaching a Terahertz (THz). These superconductor-insulator-superconductor (SIS) receivers may comprise a vital portion of any future submillimeter astronomy mission, perhaps including U.S. participation in ESA's Far-Infrared Space Telescope. slated for launch late next decade. In the meantime, continued development of heterodyne receivers are likely to lead to eventual testing in astronomical applications on ground-based telescopes and aboard suborbital platforms, including the airborne Stratospheric Observatory for Infrared Astronomy (SOFIA).

During FY 1996, 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. Laboratory measurements and/or calculations of parameters necessary for the full interpretation of remote sensing data expected to be taken by the TIMED mission are being sought. 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 effort to study the detailed interaction of solar magnetic fields and the associated flow of plasmas that lead to the variability of the Sun.

Also during FY 1996, a flight test of an advanced microcalorimeter device is planned to obtain very high spectral resolution measurements of the diffuse soft x-ray background emission from the hot interstellar medium in our Galaxy.

In the FY 1997, astrophysics program, emphasis will continue on the fabrication of space-qualified detectors with enhanced imaging and spectral capabilities in the x- and gamma-ray energy bands. In addition, innovative optical approaches for Imaging in the hard x-ray regime and the enhancement of the imaging capabilities of high-throughput x-ray telescopes will be pursued.

During FY 1997. the space physics program will seek to understand, in terms of basic physical processes, the composition and conditions in the energetic solar, interplanetary and galactic regimes that create cosmic rays, as well as to comprehend 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 durlng 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.

For the first time. astronomers have confirmed the discovery of a planet circling a star similar to our Sun. Swiss and American astronomers found a large planet (about half the mass of Jupiter) orbiting the star 51 Pegasi. 51 Pegasi is a normal star, somewhat older than our Sun, but the new planet is dramatically different from anything found in our own solar system. Despite its massive size, this planet orbits so close (about 5 million miles) that it is within the hot. tenuous outer atmosphere (the corona) of its star and completes a revolution in about 4 days. By contrast. Jupiter orbits the Sun at a distance of nearly 500 million miles and completes a revolution in about 12 years.

Investigators were competitively selected to participate in two new data analysis programs, each designed to support study of a unique dataset. About 25 scientists will conduct investigations of the moon. based on some two million multispectral images of the surface obtained by the DoD's Clementine mission: another 6 will analyze the data set from the Galileo mission encounter with Gaspra and Ida as it passed through the asteroid belt. A joint NASA-NSF program selected 35 scientists to undertake an interdisciplinary study of datasets gathered during the Comet Shoemaker-Levy 9 collision with Jupiter.

"An Exobiology Strategy for Mars Exploration," published this year, considers exploration search strategies to determine whether life ever evolved on Mars. Representing the synergistic culmination of two workshops, the writings of 18 Mars scientists recommend a progressive series of missions from orbital global surveys to successive landed missions.

A NASA-formed Science definition team for the Pluto Express mission produced a report defining a small, highly focused mission to the last unexplored planet in our solar system. The mission would be carried out by two flyby s p a c e d each bearing a highly integrated instrument set capable of making those measurements deemed essential to characterize the Pluto/Charon binary system. The Pluto Express program may be implemented cooperatively with Russia and/or Germany.

Early in 1995. NASA formed the Near-Earth Objects (NEO) Survey Committee to assess the nature of the Earth collision threat and to recommend ways to deal with it. The committee report has not been submitted to the OMB; the report calls for investment in a 2 meter telescope and development of detectors and software utilizing current technology. The objectives of the NEO survey are to detect, characterize. and catalogue all comets and asteroids greater than 1 km 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.

The Exploration of Neighboring Planetary Systems (ExNPS) roadmap activity has been initiated. Three independent groups were formed and each was asked to develop a strategic plan for a program to detect and then characterize the properties of planetary systems around neighboring stars. An integration team has now combined the best aspects of each plan and will present the synthesized roadmap to NASA early in 1996.

The Solar Electric Propulsion technology development completed successfully 2000 hour ground tests that permitted the update of a performance prediction model. A follow up 1000 hour ground test verified the reliability and the accuracy of the model. Industrial contracts were awarded competitively for the flight hardware to be provided to the first mission of the New Millennium program.

During FY 1995, SIRTF continued in Phase A. Consideration was given to flying one of the three SIRTF instruments on the Japanese Astro-F mission. This proved impractical given the limited capability of the Japanese rocket. Meanwhile, due to major savings in mass resulting from innovative redesign, SIRTF was able to reincorporate the third instrument with little trouble. A launch into solar orbit using a Delta II rocket is now baselined. In addition to introducing innovative design changes, the SIRTF team has worked closely with the aerospace industry, and as a result has devised a management plan that combines JPL and industrial contractors into working teams that should significantly reduce the mission's cost while improving the mission's quality. A new type of beryllium mirror was cryo-tested and found to be suitable for SIRTF. During FY 1996, the design of SIRTF will continue to be refined, a full beryllium telescope will be cryo-tested at JPL, an RFP will be issued to industry. and the mission will move into Phase B in October 1996. The three SIRTF instruments require five different detector types to span the broad wavelength coverage extending from the near-infrared (afew microns) to the far-infrared (200microns). The key performance specifications for each of these detector types are close to being achieved. and detector development efforts in FY 1996 are expected to meet or exceed the necessary requirements in time for a SIRTF phase B start in FY 1997.

The SOFIA program successfully passed its final Non-Advocate and Program Management Council reviews in FY 1995. The program baseline was altered to combine development and operations under one private sector prime contract. A draft RFP was circulated, and technical exchange meetings and workshops were held to transfer technology from NASA to the private sector to accomplish the privatization goals. Beginning in FY 1996, funding for SOFIA development is carried in the Suborbital line.

Sun-Earth connections ATD activities in FY 1996 and FY 1997 include continuing definition studies of missions emphasizing the use of small spacecraft and rapid development, including the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED). High Energy Solar Physics (HESP), Magnetospheric Imager (MI), and Solar Probe missions. As a result of continuing pressure to reduce the size and cost of future missions, the TIMED mission has been descoped. Five of the nine originally selected instruments wen deselected in October 1994. While maintaining the highest priority science, the development costs for the TIMED mission have been reduced by about a factor of four from the TIMED mission conceived of several years ago. The development costs for the other three missions have also been reduced by a factor of four from the original concepts.

Comet Hale-Bopp. discovered in 1995, is expected to brighten considerably during 1996 and *may* become the brightest comet in more than a century. Building on the experience of the Shomaker-Levy 9 event, NASA and NSF are planning a two-year program beginning in FY 1996 to coordinate activities for observation and study of the comet, involving ground-based observatories, orbiting spacecraft, and sounding rockets.

Two experiments have been developed to capture Interplanetary Dust Particles (IDPs) and test the efficacy of different capture media in low Earth orbit. The experiments are planned for launch in March 1996 on the Russian module Priroda and will be deployed as attached payloads of the phase lb NASA-Mir Program. IDPs carry critical and unique information on processes in the early Solar System and Interstellar Medium, the evolution of interstellar organics, and the origin of life.

The Keck Observatory will become available to NASA scientists with the completion of the Keck 11 telescope in late 1996. These twin, 10 meter telescopes. that are the largest in the world, will allow NASA astronomers to begin searches for extra-solar planetmy systems around other stars with significantly greater sensitivity than has been possible with any other telescopes.

Selection of instruments for the ESA Rosetta mission to Comet Wirtanen will be completed in early 1996. Those instruments. for either the Rosetta Orbiter or the Champollion Lander. to be funded by NASA will then begin a one-year design/accommodation phase leading to confirmation in 1997. During the accommodation phase issues such as mass reduction. integration with other instruments, technology development, and determination of actual development cost will be studied.

The ExNPS roadmap activity will be completed and the study team's final report submitted in FY 1996. One of the first actions for NASA in implementing the roadmap plan will be to issue a NASA Research Announcement soliciting proposals for the first ExNPS dedicated instrument to be developed for the Keck II telescope.

The Announcement of Opportunity (AO) for Pluto Express instruments will be issued in FY 1996. The AO will call for an instrument design which is highly integrated with other spacecraft elements and subsystems, in order to reduce mass, power, volume, and cost.

Comet Hale-Bopp reaches perihelion, its closest approach to the Sun, in April 1997. The NASA-NSF coordinated observing campaign will reach its peak of activity during this period of maximum comet brightness.

Early in 1997 NASA will competitively select a group of participating scientists to augment the Mars Pathfinder mission science teams. These scientists will be supported to prepare models and data analysis tools in preparation for the Pathfinder landing in July 1997.

The Keck II telescope will become operational and ready for NASA supported users in October 1997. Throughout this fiscal year, both planning and hardware development will continue toward the goal of establishing an interferometry capability at the Keck facility by 1998. This will ultimately involve housing equipment required to combine the two Keck and four outrigger telescopes.

Development of selected Pluto Express instrumentation will begin in FY 1997, and negotiations wlth potential mission partners (Russia and/or Germany) will result in a specific definition of the role/contribution of each partner.

Also in FY 1997, the Solar Electric Propulsion technology development will complete the ground test and evaluation phase for the flight components to be tested in the first Deep Space mission of the New Millennium program. It will deliver the propulsion unit and diagnostic system to the spacecraft.

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. The growth in international connectivity through the Internet is especially dramatic in enhancing scientific collaborations around the world.

Advanced visualization and animation capabilities developed under this program are most evident in the animations supporting the Galileo mission and the 'real-time" fly-over of Mars using the 3-D global Viking data.

The Remote Exploration and Experimentation (REE) project is conducting short-term study contracts with industry and academia in FY 1996 to establish requirements, identify candidate designs and architectures and qualify potential methodologies. Beginning in FY 1997, REE will complete a detailed Project Implementation Plan with milestones and metrics, and will issue technology system development contracts to industry and academia.

As a result of the Zero Based Review, options for "privatizing" science data archiving are being evaluated. This will be evaluated in the context of the future OSS data environment featuring interdisciplinary studies and the role of NSSDC in that environment, with the intent to strengthen the community-based nature of the activity. In the area of networking, means to outsource this service are also being evaluated.

The program will continue to incorporate newer, more cost effective technologies, but the tightly constrained fiscal environment will curtail much of the initial investments needed to achieve the efficiencies. Start-up or transition costs associated with privatization of science data archives is also a concern.

BASIS OF FY 1997 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Airborne program			
Kuiper airborne observatory	13,200	3,400	--
Stratospheric observatory for Infrared astronomy	--	30,000	26,300
Balloon program	16,000	16,000	14.000
Sounding rockets	38.000	38.600	28.800
To	67.200	88.000	69.100

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.

STRATEGY FOR ACHIEVING GOALS

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 Stratospheric Observatory For Infrared Astronomy (SOFIA) is a new airborne observatory designed to replace the aging Kuiper Airborne Observatory (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. Development of SOFIA will start in FY 1996, with initial operations by the end of 2000. KAO operations have been terminated; 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 government-owned, contractor-operated facility in Palestine, Texas.

Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and s p a c e d 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 are 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 1995	51 science flights, plus two "Live from the Stratosphere" flights televised on PBS. vs. approximately 40 flights planned.
FY 1996	KAO operations terminated in October 1995.

SOFIA:

RFP Released		Request for Proposals from industry for the SOFIA development and operations prime contract.
Plan:	February 1996	
Current:	February 1996	

NASA/DARA MOU signed Plan: April 1996 Current: April 1996	Anticipated date for formal agreement between NASA and the German Space Agency.
Prime contract award man: August 1996 Current August 1996	Selection of the SOFIA development and operations prime contractor.
System PDR man: June 1997	Preliminary design review of entire SOFIA system, in U.S. and Germany.
Balloon: FY 1995	16 flights achieved vs. 20-25 planned. Antarctica campaign (2 flights) served as engineerlng test flights for new Instruments designed to increase statistical data derived from 1994 campaign on the origin. energy and composition of cosmic rays. The Australian campaign (5 flights) was initiated and will continue through early FY 1996. These flights are measuring gamma ray emissions from the Galactic center and studying selected celestial objects that can only be observed in the Southern Hemisphere.
FY 1996	A minimum of 30 flights are planned, including 2 long-duration missions over Arctic regions which will re-fly new Instruments flown over Antarctica in FY 1995 campaign.
FY 1997	A minimum of 20 flights are planned.
Sounding Rockets: FY 1995	30 flights achieved vs. 30-35 planned. Poker Flats campaign (7 flights) studied a variety of auroral acceleration processes and their effects on the Earth's upper atmosphere.
FY 1996	Approximately 32 flights planned. International Australia campaign (5 flights) will conduct astrophysics observations unachievable from the northern hemisphere.
FY 1997	A minimum of 20 flights are planned.
Spartan: Spartan 201 man: July 1995 Accomplished: July 1995	Space Physics mission conducted investigations of solar wind as correlative data measurements to Ulysses.

ACCOMPLISHMENTS AND PLANS

In 1995, the KAO flew 51 research flights that involved 25 Principal Investigators and logged more than 300 hours of observation time. In addition, 34 teachers from grades K-12 were given the opportunity to fly aboard the KAO. Operations of KAO have been terminated as of October 1995. The savings from cessation of KAO operations are an integral element of the funding plan for SOFIA.

The SOFIA program successfully passed its final Non Advocate and Program Management Council reviews in FY 1995. The program baseline was altered to combine development and operations under one private sector prime contract. A draft RFP was circulated, and technical exchange meetings and workshops were held to transfer technology from NASA to the private sector to accomplish the privatization goals. In FY 1996 NASA plans to release the final RFP for development and operations, and select the prime contractor. We expect to execute an international Memorandum of Understanding between NASA and DARA in April 1996. The contractors on both sides of the Atlantic will initiate final design work, heading toward an integrated Preliminary Design Review in June of 1997.

In FY 1995, 30 sounding rockets and 16 balloons were flown. Of particular interest was completion of the highly successful sounding rocket campaign in Brazil in which 13 rockets were flown to study the ionosphere at the Earth's magnetic equator. Recent developments in long-duration ballooning now make it possible 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 is now being used in polar campaigns to fly cosmic ray experiments where the event rate is especially low. Funding in FY 1996-FY 1997 will support the planned balloon and 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 occurred in 1995 to provide correlative data for the Ulysses mission during its passage over the northern solar pole. Spartan missions planned for FY 1996 support two experiments developed in the Space Access and Technology program.

BASIS OF FY 1997 FUNDING REQUIREMENT

LAUNCH SERVICES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Launch services	255,600	254,300	253.500

PROGRAM GOALS

To provide successful, on-time launch services for the Space Science missions at the least possible cost. hunch Services are a vital element in the achievement of the overall goals of the Space Science program. Expendable hunch Vehicles (ELVs) provide safe, reliable, timely and cost-effectivelaunch services for Earth orbiting and planetary missions

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 provided by the Orbital Sciences Corporation (OSC) and requires in-flight deployment from a Lockheed L101 1 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 provlde 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 provided 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-Ute 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-Ute 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).

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 Lockheed Martin Corporation (LM). NASA is procuring the Titan IV/Centaur launch vehicle for

Cassini via an existing contract between the United States Air Force (USAF) and LM. A separate contract for mission unique integration activities is established directly between NASA and LM.

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.

MEASURES OF PERFORMANCE

Polar launch Plan: Current:	 December 1995 February 1996	Launch aboard a Delta 11 from Vandenberg Air Force Base (VAFB) delayed from mid-1994 to December 1995 due to technical problems with spacecraft. Delay from December 1995 is due to launch vehicle delays.
SWAS launch Plan: Current:	 July 1995 TBD	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.
FAST launch Plan: Current:	 August 1995 TBD	Launch from VAFB aboard the Pegasus XL/L1011 launch vehicle. Exact date of this launch is dependent upon successful nturn to flight of the redesigned Pegasus XL launch vehicle.
SAC-B/HETE launch Plan: Current:	 Mid-late 1995 TBD	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.
TERRIER launch Plan:	 April 1997	Launch aboard a Pegasus launch vehicle.
SNOE launch Plan:	 May 1997	Launch aboard a Pegasus launch vehicle.
NEAR launch Plan: Accomplished	 February 1996 February 1996	Launched February 17, 1996, aboard a Delta II launch vehicle.
Mars Global Surveyor launch Plan:	 November 1996	Launch aboard a Delta II launch vehicle. On schedule.

Mars Pathfinder launch Plan: December 1996	Launch aboard a Delta 11 launch vehicle. On schedule.
Cassini launch Plan: October 1997	Launch aboard a Titan IV/Centaur launch vehicle. On schedule.

ACCOMPLISHMENTS AND PLANS

The SOHO mission was successfully launched aboard an Atlas IIAS on November 1995.

The X-ray Timing Explorer (XTE) was successfully launched aboard a Delta 11 on December 30.1995.

NEAR was launched aboard a Delta 11 launch vehicle on February 17,1996.

FY 1996-1997 launch services funding will support future launches of the TRACE and WIRE Small Explorer missions on small launch vehicles: the FUSE Explorer mission on a Med-Ute launch vehicle: the ACE Explorer mission on a medium launch vehicle: the new Medium Class Explorer (MidEx) on a Med-Ute launch vehicle: the Student Explorer Demonstration Initiative (STEDI) and the University Explorer Class (UNEX) missions on the Ultra-light launch vehicles: and the Gravity Probe B (GP-B) on a Delta-11 launch vehicle.

Medium class launch services funding provides ongoing support for Delta 11 launch vehicles for the Near Earth Asteroid Rendezvous. Mars Pathfinder, and the Mats Global Surveyor missions currently scheduled for launch during 1996.

Med-Ute launch services provided in FY 1996 supports initial procurement of two Med-Ute launch vehicles for the Mars Surveyor program in support of the December 1998 launch opportunity. Initial funding is also provided to procure a Med-Ute launch vehicle for Stardust.

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 Lockheed Martin-(LM) which is being procured for NASA by the United States Air Force (USAF). Funds also support mission integration activities at LM which are funded under a contract directly between NASA and LM.

Life and Microgravity
Sciences and
Applications

SCIENCE, **AERONAUTICS AND TECHNOLOGY**

FY 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

SUMMARY OF RESOURCE REQUIREMENTS

	FY 1995	FY 1996	FY 1997	Page Number
		(Thousands of Dollars)		
Life sciences				
Research and analysis	50,700	55,200	49,800	SAT 2-6
Flight program	89,800	81,200	56,400	SAT 2-14
Subtotal	140,500	136,400	106,200	
Microgravity science research				
Research and analysis	30,400	30,200	33,600	SAT 2-22
Flight program	97,100	102,800	110,700	SAT 2-28
Subtotal	127,500	133,000	144,300	
Space shuttle/spacelab payload mission				
Management and Integration	102,300	77,600	54,400	SAT 2-35
Aerospace medicine/occupational health	6,600	8,000	6,500	SAT 2-43
Space station payload facilities	90,500	133,500	187,100	SAT 2-47
Total	467,400	488,500	498,500	

SCIENCE, AERONAUTICS AND TECHNOLOGY

FY 1997 ESTIMATES

BUDGET SUMMARY

Distribution of Program Amount by Installation

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Johnson Space Center	117,200	122,300	102,300
Kennedy Space Center	29,000	10.200	13,600
Marshall Space Flight Center	126,000	113,400	114,000
Ames Research Center	63.700	73.100	100,300
Langley Research Center	1,200	3,400	3,300
Lewis Research Center	72,900	76,200	83,800
Goddard Space Flight Center	200	300	200
Jet Propulsion Laboratory	3,800	13,400	14,300
Headquarte	53,400	76,200	66,700
To	467,400	488,500	498,500

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

PROGRAM GOALS

The NASA Life and Microgravity Sciences and Applications program leads the Nation's efforts in 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; 2) develop and provide technologies and research data essential to design and operate space-based systems: and 3) maximize the health, well-being and productivity of humans in the exploration and utilization of space.

The Life and Microgravity Sciences and Applications program is carried out at 8 of the 9 NASA Field Centers under the direction of the NASA Headquarters' Office of Life and Microgravity Sciences and Applications (OLMSA).

Life Sciences and Microgravity Research and Analysis programs support ground-based research and definition studies upon which flight experiments are based. The flight programs in life sciences and microgravity science 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 (ISS). 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, is conducted through NASA Headquarters. The OLMSA also manages the Space Station Payload Facilities development program which develops research facilities for the ISS. The Aerospace Medicine and Occupational Health Division maintains the health and productivity of astronauts and develops requirements for medical operations and research.

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 (NM) 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 Me support and extravehicular technologies. It works closely with the scientific community to develop a broad variety of multi-user research facilities designed to support the Me 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) Microgravity Physics. Ground-based research facilities include laboratories, drop-tubes, drop towers and parabolic aircraft.

The Microgravity Science Flight program, consisting of a Space Shuttle/Spacelab 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 scientiflc 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 integrates the scientific payloads into the various carriers, trains payload specialists, and performs system management and engineering development of flight equipment and software.

The Aerospace Medicine and Occupational Health program is responsible for maintaining and providing medical support to optimize the health. safety and productivity of our astronauts in space. and for protecting and promoting the health and safety of all NASA employees. The program develops medical operations requirements, and develops technologies and applications including telemedicine and global health applications.

NASA is continuing to develop and broaden its cooperative research programs with Russia. The keystone of those efforts is the Phase I NMRP that includes nine missions to the Mir Space Station. This includes two recently-added missions to Mir in 1998. This program will provide NASA with opportunities to conduct long-duration, on-orbit research in life sciences and microgravity science and space medicine.

As NASA moves into the Space Station era, there will be a major transition from the current on-orbit experimentation program to the ISS. The core of the Space Station program will be seven 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), Fluids/Combustion Facility (FCF) and the Low Temperature Microgravity Physics Facility (LTMPF). In addition to the seven major facilities, NASA will develop Laboratory Support Equipment and the Expedite the Processing of Experiments to Space Station (EXPRESS) racks for the station.

As a result of the NASA's FY 1995 Zero Base Review, the concept of science institutes was identified as a potential beneficial approach to maintain or improve the quality of national science in the face of organizational streamlining. The recommendation was made to reshape NASA's science program under a reinvention strategy to bind NASA's science program more closely to the larger science community that it serves. The strategy involved 'privatization" of a portion of NASA's science program into a number of science institutes. A NASA Science Institute would be a non-federal entity that would: 1) accomplish an ongoing research program: 2) provide services to the scientific community and the public: and 3) facilitate scientiflc and industrlal community access to NASA's space and ground-based assets.

The NASA Science Institute plan was developed in 1995. The plan identifies eleven possible new institutes for NASA; the Life and Microgravity Science and Applications program would establish four of these institutes. The first Science Institute is planned to be the National Institute of Space Life Sciences at or near the Johnson Space Center in Houston, TX. That institute, currently scheduled to begin operations in FY 1997, will lead a national and international effort for accomplishing the biomedical research necessary to support long-term human presence, development and exploration of space. It will also work to enhance life on Earth by applying the resultant advances in human knowledge and technology acquired through living and working in space.

BASIS OF FY 1997 FUNDING REQUIREMENT

LIFE SCIENCES RESEARCH AND ANALYSIS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Life sciences research and analysis	50,700	55,200	49,800

PROGRAM GOALS

The Life Sciences Research and Analysis (R&A) 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 utilize gravity. microgravity and 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 of time: and 3) to apply this knowledge and technology to improve our Nation's competitiveness, education. and the quality of life on Earth.

The 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 night on humans. Life Sciences Research and Analysis pursues its goals through ground-based research programs and projects at universities, NASA Centers, nonprofit and industrial organizations. and other Federal agencies. It also finances specialized support facilities and technologies in support of the science community.

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 psycho-social 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 additional specialized activities and services. Its 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 of all ages to consider careers in space life sciences, and sponsors development programs aimed at those already engaged in life sciences research careers.

All Research and Analysis investigations that the Life Sciences program sponsors are peer-reviewed. consistent with revised competitive 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 competitive review standards as those of extramural researchers. The Life Sciences program's policies permit peer reviews of selected proposals to be performed under cooperative arrangements with the NIH.

The Space Biology program seeks to improve understanding of the role of gravity in biological processes by using a variety of gravitational environments 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. and plant biology. Its research includes plants or animals as subjects, as well as cell or tissue cultures.

The Space Physiology and Countermeasures program supports research that seeks to characterize and determine the mechanisms of physiological changes in weightlessness, including those that threaten to limit the duration of human space missions. It also develops methods that allow humans to live and work in microgravity, that optimize crew safety, well-being, and performance, and that minimize the deleterious effects of returning to Earth's gravity after spaceflight.

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 sponsors research to establish the scientific basis for protecting humans engaged in the development and exploration of space from radiation hazards. The program seeks to establish a firm knowledge base to support 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 pursues multiple objectives. It works to expand knowledge of human psychological and physical capabilities and limitations in space. It develops technologies that integrate the human and system elements of space flight. It encourages mission planners to use human factors research results and technology developments to improve mission results and crew safety. The program makes NASA technologies available to the private sector for Earth applications.

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 while minimizing the need for resupply. 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 develop technologies for growing, harvesting, and processing crop plants for flight crew consumption.

The Advanced Extravehicular Activity (EVA) Systems program develops new technologies necessary to perform EVAs productively. safely. and efficiently during future long-duration missions. 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. 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.

Center Support

The Life Sciences Research and Analysis program manages its projects, activities, and tasks from Headquarters and the following NASA Centers: the Ames Research Center (ARC). the Johnson Space Center (JSC), and the Kennedy Space Center (KSC). The program also draws upon other Centers on occasion to administer tasks or for other unique expertise. Following the program's adoption of revised peer review procedures during FY 1994, NASA returned the responsibility for extramural grants management to Headquarters. Center researchers continue to perform intramural peer-reviewed research and technology projects and tasks as well as applied research and technology tasks. The Centers also maintain unique research facilities that support the investigations of extramural and intramural researchers alike.

NIH Cooperation

Within Life Sciences, $10.0 million each year supports collaborative activities with the NIH, of which more than $5.0 million is supported under the R&A program. Life Sciences resources dedicated to joint NASA/NIH collaboration are likely to increase in future years, stimulated both by the success of past collaborative efforts and by the recommendations of the NASA/NIH Interagency Advisory Committee. A key collaborative venture between NASA and NIH is the Human Brain project, which concentrates on neural science and informatics research. NASA and 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 that NASA Life Sciences has underway with NIH include several

projects in cancer research, including a technology development task which aims to develop advanced digital mammography techniques. NASA and the National Cancer Institute (NCI) are jointly supporting radiation biology research into the fundamental processes leading to cancer. This research will provide benefits for extended space flight and occupational health. NASA and NIH 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 developed in collaboration with the National Library of Medicine (NLM), recently became available for use.

The program also participates with other Federal agencies such as the Department of Energy (DOE), the Department of Defense (DoD) and a variety of other national and international organizations whose research interests intersect those of the program. These organizations include the National Science Foundation. the American Society for Gravitational and Space Biology [ASGSB], the Aerospace Medical Association (AMA), and the American College of Sports Medicine (ACSM). The program also reaches out to groups whose members are underrepresented in the life sciences research community. such as the Alaska Native Association (ANA).

MEASURES OF PERFORMANCE

	FY 1995	FY 1996	FY 1997
Number of Principle Investigators supported	198	224	232
Number of Co-Investigators supported	257	291	302
Number of Graduate Students supported (flight and ground)	632	632	622
Number of Refereed Publications (flight and ground)	500	540	600

Release Life Sciences NASA Research Announcements — Ensure a steady source of peer-reviewed research and development tasks.

Plan: 1st Qtr FY 1995
Actual: 2nd Qtr FY 1995

Plan: 1st Qtr FY 1996
Actual: 2nd Qtr FY 1996

Plan: 1st Qtr FY 1997

Complete 5-year performance period for NSCORTS/recompete — NSCORTS in Gravitational Biology, Bioregenerative Life Support, and Environmental Health will conclude during FY 1995.

Plan: 4th Qtr FY 1995
Actual: 4th Qtr FY 1995

FY 1995 was a period of significant activity for the Life Sciences Research and Analysis program. The program solidified gains made during FY 1994 to improve the quality of the program's peer review processes. In response to an FY 1995 Research Announcement, Space Life Sciences selected 47 proposals in late FY 1995 to receive two and three-year grants for conducting ground-based or space-borne life sciences research and development investigations valued at approximately $15 million through FY 1998. Thirty-six of the proposals selected will receive budgetary resources from the Life Sciences Research and Analysis program in FY 1996; the remainder will receive flight program resources or will be funded by NASA's international partners. Awards initiated with FY 1996 resources will continue. in most cases, through FY 1998. During FY 1995. the Research and Analysis program continued a long tradition of building collaborative relationships with non-NASA researchers. and the program successfully demonstrated a number of promising new technologies. A number of Life Sciences' collaborative and technology development activities have already begun yielding benefits in ground-based applications.

During FY 1996 and FY 1997, the space biology program will maintain its focus on advancing fundamental knowledge in the biological sciences using the tool of gravity and microgravity. The program plans to award nine new peer-reviewed research grants in FY 1996. FY 1996 and FY 1997 investigations, including renewals and new awards, will concentrate on the areas of cell biology. developmental biology. plant biology, and systems biology. Cell biology investigations will examine how gravitational information is transduced, how cells respond to acute and long-term variations in gravity, and how gravity affects the composition, size, shape. and function of cells. Developmental biology investigations will study the influence of gravity and microgravity on animal growth, development, reproduction. genetic integrity. Me span, senescence, and subsequent generations of animals. Plant biology investigations will conduct research to understand how plants perceive, transduce, and respond to gravitational force. The investigations will elucidate the role of hypergravity and microgravity in developmental and reproductive processes in plants, and will seek to understand the role of hypergravity and microgravity in the metabolism and transport processes in plants. Systems biology investigations will study the ways in which organisms sense and integrate gravitational information, and how organisms facilitate orientation and locomotion. Systems biology investigations will also test mechanisms of gravitational adaptation. and they will support research that attempts to determine the gravitational influence on genetic expression relating to physiologic function, such as rhythms, stature, and locomotion.

During FY 1996 and FY 1997, the space physiology and countermeasures program will concentrate on the problems associated with extended stays in space, especially stays of 90 days to 180 days, in preparation for the International Space Station era. During FY 1996, the program plans to award thirteen new peer-reviewed research grants. FY 1996 and FY 1997 resources will fund both basic and applied research on the effects of hypogravity and hypergravity. Studies may include human and animal subjects. The program will seek new techniques for the non-invasive. in-flight measurement of the variables that characterize all systems. It will also address the development of an optimal exercise protocol for space flight to provide 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 systems and technologies programs will shift the focus of their ground-based activities durlng FY 1997 toward the development of technologies that will support NASA's needs during the ISS era and for the Human Exploration and Development of Space. Life Sciences environmental systems and technologies programs include the environmental health

program, the radiation health program, the space human factors program, the advanced life support and advanced EVA programs, and the Advanced Technology Development (ATD) program.

The environmental health program will conduct research that will help to establish space flight environmental standards for human health and performance. During FY 1996, four new peer-reviewed research awards are planned in the environmental health program; three of which will yield crosscut benefits with the ATD program. The program will use FY 1996 and FY 1997 resources to 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 rely upon ground-based studies to anticipate the effects of closed systems in space.

Durlng FY 1996 and FY 1997, the radiation health program will support ground-based experimental radiobiology studies using proton and high-energy heavy ion beams. During FY 1996. three new peer-reviewed research awards are expected in the radiation health program. FY 1996 and FY 1997 resources will support studies attempting to understand the mechanisms responsible for radiation-caused carcinogenesis and the reliability of interspecies extrapolation of radiobiological effects. The radiation health program initiated a new collaborative venture with the NCI durlng FY 1995 that will continue durlng the budget period. This new NASA Life Sciences/National Cancer Institute (NCI) collaborative effort will provide up to $1.0 million per year of Life Sciences-supported research during FY 1996 and FY 1997. The collaborative project, which will also receive NCI co-funding, will attempt to define and understand the nature and extent of long-term genomic instability in mammalian cells caused by chronic low-dose radiation exposures of the kind likely to be encountered during extended space flight and in certain occupational settings.

During FY 1996 and FY 1997, the space human factors program will emphasize both research and technology development. In FY 1996, four new peer-reviewed space human factors awards are planned. The program will conduct research to document human performance responses to long-term space flight, including especially those that affect the performance of safety-critical functions. This research will attempt to understand the factors that influence space-based performance. The program's research activities will use human-machine scenarios, models, analogs, and other tools as aids in defining human habitability requirements for space flight and in developing design and performance requirements for equipment, procedures, operations and environments in space and on the ground. The program will support the development of new designs. technologies, and systems needed for space and ground-based operations with particular emphasis on advanced displays and controls. human-machine function allocation, interactions among intelligent agents. and intravehicular activity and extravehicular activity.

The primary emphasis of the advanced life support program durlng FY 1996 and FY 1997 will be on technology areas that have clear and compelling relevance to NASA during the ISS era and that will enable the Human Exploration and Development of Space. The advanced life support program will not initiate new peer-reviewed investigations during FY 1996. The program will, however, demonstrate the feasibility of using higher plants to provide air, water and food for planetary surface life support systems, demonstrate the maturity of physical/chemical recycling processes for providing air and water for planetary life support systems and complete the evaluation of continuous cropping of potato and wheat, including the recycling of nutrients from inedible plant biomass through aerobic bioreactors. Its technology development activities will include completing the development of a fully automated. on-line monitor for microbes affecting crop growth. The monitor will provide for 96 specific tests and will issue alerts

to astronaut crews. In yet another technology test. the program will use human liquid wastes, process them through aerobic bioreactors, and reuse them to grow plants in a closed environmental chamber.

As part of NASA's continual effort to ensure program relevance. the Closed Environmental Life Support System (CELSS) Test Facility at the KSC, consistent with the recommendations of NASA's FY 1995 Zero-Base Review, will be terminated in early FY 1998 and consolidated at the JSC.

Durlng FY 1996, the advanced EVA systems program requirements will be restructured in an effort to revalidate its programmatic objectives. FY 1997 resources are expected to be used to support proposals in the following areas: mission requirements definition; EVA human factors; physiological and medical requirements: EVA task requirements; systems studies; and EVA mission operations. Activities in this program area. pending the outcome of revalidation activities, will support such initiatives as the development of next generation EVA systems technologies. Life Sciences' advanced EVA systems program expects to continue a collaborative program with the multiple sclerosis community that is seeking to develop micro-climate technologies. The goals of this project are to help establish cooling protocols for multiple sclerosis patients and to coordinate a nationwide clinical study that will determine the medical efficacy of cooling for these patients.

The primary emphasis of the advanced technology development (ATD) program durlng FY 1997 will be on environmental sensors and biosensors. Durlng FY 1996, four new peer-reviewed awards are planned in the program, three of which will generate crosscut benefits with the environmental health program. The ATD program will concentrate in particular on developing new technologies for air and water monitoring and microbial detection, as well as refining and micro-miniaturizing currently available sensors. The program will also support the development of advanced implantable biotelemetry systems.

Also during FY 1996, the data analysis program will maintain its customary emphasis on extended data analysis and on enabling the research community's access to data. Life Sciences will initiate two new peer-reviewed data analysis awards during FY 1996. Secondary emphasis will be on the area of special data analysis techniques. NASA and NIH collaborations have yielded particularly fruitful results in Life Sciences' data analysis program. and the program will seek to build upon these past successes. SPACELINE bibliographic database capabilities will expand during the budget period, owing to the continued support provided by the National Library of Medicine. Additional data archiving and database products will be developed in FY 1997 for the benefit of the research community during the era of the ISS.

During the past year, Life Sciences successfully recompeted NSCORTs in gravitational biology, bioregenerative Me support, and environmental health. North Carolina State University in Raleigh will receive a new NSCORT award for gravitational biology, and an additional gravitational biology NSCORT will be established at Rice University. Wake Forest University will be a collaborating partner in the North Carolina State University NSCORT, while the JSC will be a collaborating partner with the new Rice University NSCORT. Rutgers University will receive an NSCORT for bioregenerative Me support, and the Stevens Institute of Technology in Hoboken, New Jersey will be a collaborating partner. The new NSCORTs will each receive a five year award that will be initiated durlng the first half of FY 1996.

Collaboration or joint sponsorship of workshops and related activities during FY 1995 included a jointly sponsored workshop with the NIH's National Institute of Environmental Health Sciences at which researchers gathered to discuss recent research results in environmental health. A workshop sponsored with the National Foundation for Brain Research presented Life Sciences contributions to the 'Decade of the Brain." Additional opportunities for life sciences researchers to present their research findings occurred through participation with such organizations as the ASGSB, the American Physiological Society. and the American College of Sports Medicine.

During FY 1995, NASA and the National Cancer Institute (NCI) co-sponsored applied research and development projects designed to lead to new breast cancer digital imaging techniques. Deriving from a long-standing agreement between NASA and the NCI, innovative breast cancer imaging techniques that were recently selected from a NASA/NCI competitive solicitation are expected to lead to highly effective, low-cost diagnostic technologies. This collaborative venture will continue in FY 1996 and FY 1997. The payoff from this effort might be huge. Recent statistics show that 186,000 new cases of breast cancer were diagnosed in the U.S. alone in 1993. Health care costs associated with breast cancer in the U.S. exceed $8 billion annually.

An active Research and Analysis-based outreach program is planned for FY 1996 and FY 1997. including outreach activities designed to attract Native Americans to careers in the space life sciences and related engineering disciplines. Outreach programs for Native Americans attempt to develop the telecommunications information infrastructure of Tribal educational organizations. Life Sciences also expects to initiate a Native American Earth and Space Academy (NAESA) during FY 1996 and to provide internet connectivity to the Navajo Community College and the Headquarters of the Cherokee Nation of Oklahoma's Sequoyah High School. Finally, Native American outreach programs will team with the Air Force Office of Scientific Research to support the Navajo Community College Telecommunications Infrastructure Development program durlng FY 1996, along with the planning for the All Indian Nations Forum on Telecommunications.

The Research and Analysis program will continue to encourage extramural investigators to take advantage of NASA-unique facilities to support research objectives. The program will use FY 1996 and FY 1997 budgetary resources to increase extramural access to the Biocomputation Center. the Vestibular Research Facility and other radial acceleration facilities at the ARC, along with the KC-135 flight program and other biomedical facilities at JSC. During FY 1995, the value of NASA's unique facilities were amply demonstrated when Life Sciences hosted a bedrest study at ARC in preparation for the upcoming Life and Microgravity Spacelab (LMS) mission. For a modest cost, the bedrest study enabled LMS investigators to evaluate their flight mission protocols and procedures well in advance of the FY 1996 flight, which in turn has allowed the investigators time to make adjustments in order to improve the science returns from the mission.

BASIS OF FY 1997 FUNDING REQUIREMENT

LIFE SCIENCES FLIGHT PROGRAM

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Flight experiments program	72,900	54,400	32,000
NASA/Mir research program	16.400	19,800	13,200
Space station utilization program	500	7,000	11,200
To	89,800	81,200	56,400

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 development work provides the scientific and technological foundations for a safe, productive human presence in space for extended periods.

STRATEGIES FOR ACHIEVING GOALS

The Life Sciences Flight Experiments program strives to select 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 activities. 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 flight opportunities are provided to the highest ranked. peer-reviewed research and technology projects.

The Life Sciences Flight Experiments 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 Shuffle cargo bay as well as Space Shuttle small payloads. As the nation approaches the era of the International Space Station, the Life Sciences Flight Experiments program has begun taking advantage of longer-duration flight opportunities aboard the Mir space station. The NASA/Mir Research program investigations will enable the Life Sciences Flight Experiments 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 Experiments 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 Experiments program develops and demonstrates applied technologies. Successful application. for example, of the advanced life support technologies which the Life Sciences Flight Experiments program develops will enable crews engaged in long-duration flights to recycle food, air, and water mort effectively and economically. It will enable crews to grow, harvest, and process crop plants for their own consumption. The Life Sciences Flight Experiments program's applied technologies programs will enable the development of advanced facilities and other resources for use aboard the ISS. The Life Sciences Flight Experiments program also develops technologies, experiments, and protocols which promise to minimize risks to crew health.

The Life Sciences Flight Experiments program develops and supports investigations in the areas of biology, physiology, environmental, psycho-social. and neurological sciences for Spacelab flight opportunities. The program's budgetary resources enable 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 traditionally become available about every two-three years. The next scheduled Me sciences Spacelab flight, in the third quarter of 1996, is the Life and Microgravity Spacelab mission (LMS); the last scheduled Me 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 Experiments program also relies upon Space Shuffle 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. space physiology and countermeasures, 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, 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 Experiments program will conduct long-duration science aboard the Russian Mir space station. as well as science investigations on the Space Shuttle rendezvous missions to Mir. NASA plans nine Phase I Space Shuffle missions to Mir, with the last flight scheduled for mid-FY 1998. Life Sciences will also support research investigations in environmental monitoring and countermeasures aboard the Mir. These investigations will emphasize musculoskeletal, cardiovascular, regulatory physiology, and neuroscience research, along with plant biology and other fundamental biology research.

The Biorack facility, previously developed by the European Space Agency (ESA), will fly on three of the Space Shuffle 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 the influence of gravity on cellular functions and developmental processes in plant and animal tissues.

NASA will also use Mir to perform flight experiments in environmental control, advanced life support systems, and advanced space station crew health care systems. These investigations will reduce technical, schedule, and cost risks associated with the development and operation of the ISS.

In cooperation with the Russian Space Agency (RSA) the Life Sciences Flight Experiments program conducts biological experiments with non-human primates on unmanned biosatellites. The uncrewed Bion series of biosatellites flies biological and radiation measurement experiments in near-Earth orbit. Since 1973, the Republic of Russia (formerly the U.S.S.R.) 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 missions with primates last up to fourteen days.

Contractor and Center Support

The participating Centers in life sciences' flight research activities and programs include the Johnson Space Center (JSC), which leads in the development and support of life sciences investigations in the areas of space physiology. environmental and human factors, and advanced life support. The Ames Research Center (ARC) leads the development of space biology research investigations and it plays the primary life sciences role in the development of primate investigations scheduled for launch aboard uncrewed biosatellite missions. Both NASA Centers participate in Spacelab flights. 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 manages small payload investigations, especially those using plants. KSC's management of advanced life support facilities is scheduled to terminate during the first quarter of FY 1998.

NASA's Centers obtain services from a variety of support contractors to fulfill their obligations to Life Sciences flight programs and disciplines. although NASA effortsto recompete and consolidate technical and support contracts are altering the mix of active firms at the Centers. The Lockheed-Martin Engineering and Science Company supports hardware and payload development tasks at JSC and at ARC. In late FY 1994. KSC selected Dynamac, Inc. to provide a 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. ARC awarded a new consolidated life sciences support contract to the Lockheed-Martin Corporation in mid-FY 1995.

International Cooperation

The Life Sciences Flight Experiments program seeks opportunities to enhance its science research and technology development activities by promoting cooperative ventures with external entities and researchers. Life Sciences' collaborative ventures with non-NASA entities extend to the foreign partners participating in the ISS program. as part of the effort to build and enhance working relationships in preparation for the Space Station era. NASA and the ESA, for example, will both *fly* investigations on the ESA-built Biorack during the NMRP. On the LMS mission. the DoD 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, nine of the twenty-two investigators selected for development during FY 1995 are international: investigators from Germany, Japan, Italy, France, and the Netherlands 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 NSF and the Office of Naval Research.

Aside from the Life Sciences program's Spacelab missions, international and domestic partners play vital roles in the Life Sciences night Experiments program's small payloads program. The French, Russian, German. Ukrainian, and Canadian Space Agencies represent about 20% of the annual small payloads 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 and Germany.

MEASURES OF PERFORMANCE

	FY 1995	FY 1996	FY 1997
Number of Principle Investigators supported	174	148	134
Number of Co-Investigators-supported	227	193	174
Number of Investigators with on-orbit experiments	178	152	134

The first phase of the NASA/Mir Research Program (NMRP) launches to Mir Plan: 3rd Qtr 1995 Actual: 4th Qtr 1995	An American astronaut spent 115 days aboard the Mir spacecraft. NASA Life Sciences conducted musculoskeletal, cardiovascular, regulatory physiology, and neuroscience investigations.
Second phase of NMRP begins. Plan: 1st Qtr FY 1996 Revised: 2nd 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 use the program to develop new life support technologies and to enhance capabilities for on-orbit environmental monitoring.
SpaceHab. Inc.'s CMAM, outfitted with the ESA's Biorack and a suite of life sciences experiments, will fly to Mir. S/MM-03: 3rd Qtr FY 1996 S/MM-05: 1st Qtr FY 1997 S/MM-06: 3rd Qtr FY 1997	NASA Life Sciences research on Biorack will investigate cellular functions and developmental processes in plant and animal tissues.

The LMS Spacelab mission flies on STS78 - 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 - 4th Qtr 1996	Bion 11 will accommodate the Rhesus investigations which had been scheduled to fly on SLS-3. The Bion 11 will conduct musculoskeletal. physiology, neurosensory, and immunology investigations, along with regulatory physiology investigations.
	The continuation of this mission is currently under review.

ACCOMPLISHMENTS AND PLANS -- Life Sciences Flight Experiments Program

During FY 1996, a major emphasis of the Flight Experiments program will be the support of the flight of the LMS mission. The mission has been manifested on STS-78 for a June 1996 night. Including late-added investigations from the small payloads area, the LMS mission is now scheduled to provide for sixteen integrated Idfe Sciences experlments in the musculoskeletal, cardiopulmonary, metabolic, behavior and performance, neuroscience, and space biology research disciplines. LMS post-flight data analysis will be conducted during FY 1997.

The LMS mission is also noteworthy for the range of collaborative arrangements associated with the mission that will improve science and minimize costs. ESA's Torque Velocity Dynamometer is expected to fly on the LMS mission. Additional agreements are pending to fly the ESA's Hand-Grip Dynamometer, the Canadian Space Agency's Torso Rotational Experiment, and the French Space Agency's Canal and Otolith Interaction Studies. The crew of the LMS mission includes two international payload specialists, one from Canada and one from France; their backups are from Italy and Spain. Remote payload operations will be attempted as a test of the concepts that Life Sciences expects to apply on the ISS.

The Life Science Flight Experiments program continued Neurolab science planning and mission development activities during FY 1995, and the flight is on target for an FY 1998 flight aboard STS-89. The Neurolab mission has developed into a key collaborative ventures between NASA and other domestic Federal Science organizations during the 'Decade of the Brain." The NIH, the NSF, and the Office of Naval Research will provide full or partial funding to seventeen of the twenty-two domestic investigations that Life Sciences is now supporting for Neurolab flight development. A total of thirty-one investigations have been selected for Neurolab development, nine of which are being funded by NASA's international partners.

The Neurolab science payload focuses on the effects of weightlessness and other aspects of the space environment on developmental and cellular neurobiology, vestibular function, spatial orientation and visuo-motor performance. autonomic nervous system regulation, sleep and circadian rhythms, and learning and behavior. Human studies, with the crew serving as subjects, and animal studies using a variety of species housed in specialized facilities, will be carried out. Five of Neurolab's thirty-one Idfe

Sciences investigations do not require the full laboratory resources of a Spacelab flight and will instead be carried out as small payload experiments.

Along with the selection of Neurolab investigations for flight development, Life Sciences Flight Experiments program's FY 1995 budgetary resources supported the acceleration of science development for the mission. Eight semi-finalist candidates for payload specialist were selected from a group of twenty-five competitors. FY 1996 resources will provide for hardware verification tests, along with the initiation of crew training late in the year. ARC and the JSC will carry out critical design reviews and ground-based flight simulation control studies. Final selection of experiments for flight will occur during FY 1997, one year prior to flight, and the Primary Payload Specialist selection for the flight will also be made during FY 1997. Integrated design reviews of experimental hardware and for the final stages of hardware development prior to integration and flight will take place in FY 1997.

FY 1996 and 1997 resources will continue to provide for an active life sciences small payloads program. NIH provides additional support to small payload program investigators. During FY 1995. the Life Sciences Flight Experiments program flew thirty-one small payload investigators. These investigations conducted research in musculoskeletal physiology, plant biology, and developmental biology. During FY 1996, the flight of the NIH/Cells-5, the latest in the NIH/Cells series of investigations, will be funded. Life Sciences will also fly the NIH/Rodent-3, which is a verification flight for Neurolab. Life Sciences will fly the Aquatic Research Facility, belonging to the Canadian Space Agency, and it will fly a number of other human performance and plant biology experiments, for a total of nine FY 1996 small payload investigations. FY 1997 resources will support the continuation of the NIH/Cells and NIH/Rodent series of investigations. along with additional life sciences small payload investigations and data analysis.

Advanced Technology Development

There were a number of notable ATD applications highlights of Life Sciences technologies in FY 1995. Working with technologies developed by the ARC and made available through the Sensors 2000 program, a Life Sciences-supported activity. pediatric surgeons at the University of California at San Francisco initiated a project to use biosensor and telemetry technology to monitor the condition of fetuses with life-threatening congenital conditions. ARC will continue to share its innovative technologies with surgeons at the University's Fetal Treatment Center. who expect to develop additional life-saving medical procedures because of their involvement with Sensors 2000 technologies. FY 1995 resources also supported a study to develop technologies and prepare a proposed development plan for a next-generation extravehicular activity (EVA) system. The major objectives of any initiative that emerges from this study will be to increase the productivity of EVA systems. These activities are planned to continue through FY 1996 and FY 1997.

NASA/Mir Research Program (NMRP)

As part of FY 1995's NMRP activities. the Life Sciences Flight Experiments program successfully conducted experiments needed to define the ISS environment. As part of the year's activities and taking advantage of the first-ever stay on-board Mir by a U.S. astronaut, the program conducted initial studies of the challenges to human physiology and behavior during long-duration space flight. The program also engaged its Russian partners in standardizing US and Russian radiation detection data. FY 1995

resources also supported the outfitting of the Priroda module. The experiment hardware it contains, along with that delivered earlier in 1995, will be used by NASA astronauts throughout the remainder of the NMRP.

During FY 1996, the program will use the NMRP to further study the physiological and behavioral changes that occur during long-duration space flight. The NMRP in FY 1996 will also provide U.S. extramural investigators with their first-ever opportunity to conduct plant and animal investigations using the Mir.

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 STS-76 durlng 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. representatives. conducted peer reviews of the Biorack proposals in FY 1995.

The Life Sciences Flight Experiments program will continue its science investigations aboard Mir through FY 1998. Also durlng FY 1997. Life Sciences will provide for the second and third Biorack flight aboard the Orbiter. Life Sciences expects to conclude its participation in the NMRP with a successful suite of research and development results in human physiology and behavior and in animal and plant biology.

In support of the Space Station program and to take maximum advantage of the NASA/Mir opportunity, the Life Sciences Flight Experiments program will use Space Shuttle flights to Mir to develop new technologies for life support and enhance capabilities for on-orbit environmental monitoring. In the life support area, Life Sciences will adapt urine processing, water processing. and atmospheric revitalization hardware designs for use as flight experiments. Life Sciences expects to use in-house and off-the-shelf designs for water and air quality testing and for crew restraints during medical procedures. Hardware procurement contracts were awarded and detailed design efforts began for all these experiments during FY 1995. Four of these life support and environmental systems experiments will be launched in FY 1996, with remaining experiments scheduled for the FY 1997 phase of the NMRP.

Bion Program

FY 1996 resources will provide for completing the development, testing, and delivery of flight hardware to Russia in support of the September 1996 scheduled launch of the Bion 11 biosatellite mission. The mission will fly the primate experiments from the canceled SLS-3 Spacelab mission. It is designed to expand our understanding and knowledge of a variety of biomedical problems in humans. It will fly investigations of the effects of weightlessness on bone, muscle, and neuromuscular structure and function, sensorimotor function. behavior. circadian rhythms. fluid and electrolyte balance, and immunology. In January 1996, Life Sciences exercised the option to fly the Bion 12, in which a mission identical to Bion 11 would fly durlng the third quarter of FY 1998. thereby completing the SLS-3 primate studies.

Space Station Utilization Program

FY 1996 and FY 1997 resources will support three essential activities in the Space Station Utilization program. First, Life Sciences intends to provide for science development support and science verification testing for principal investigators who will be

competing for the opportunity to conduct International Space Station investigations. Second, Life Sciences expects to apply limited resources to pre-flight training and Spacelab ground facility upgrades. Finally, Life Sciences expects to use Space Station Utilization resources to amplify activities that support the Human Exploration and Development of Space. Space Station Utilization activities during FY 1996 include essential science development support and verification activities and peer review support, as well as science management of key countermeasures, space biology, and other critical life sciences disciplines. FY 1996 and FY 1997 activities for training and ground support will be limited to training program development and modifications to science and technical monitoring areas that Life Sciences already operates to support Spacelab and NMRP missions and programs. Full implementation of Life Sciences plans to modify pre-existing facilities will begin in FY 1998.

BASIS OF FY 1997 FUNDING REWIREMENT

MICROGRAVITY :E RESEARCH AND SIS

	FY 1994	FY 1995	FY 1996
		(Thousands of Dollars)	
Research and analysis	30,400	30,200	33,600

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 multi-disciplined research program has been established in the areas of biotechnology, combustion science. fluid physics, materlals science and low-temperature microgravity physics. These ground-based experiments. coupled with 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 scientiflc 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 experlments emerge. in which results *are* interpreted and given scientific meaning, and from which much of the scientiflc 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 for 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 the science and engineering community and the participating NASA Field Centers to define and build a dynamic. coherent research program capable of supporting a new generation of flight investigations in the coming decade, the beginning of the space station era.

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 are selected for funding from the assessment by peer panels of technical experts on the basis 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, ten NRA's covering five disciplines have been released, and over 1400 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 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.

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 are: 1)Biotechnology: 2) Combustion Science: 3) Fluid Physics: 4) Materials Science: and 5)Low-Temperature Microgravity 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 protein structures. In principle, such infoxmation 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 bforeactor developed by NASA 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 combustion, which is responsible for producing *85%* of the worlds energy as well as a significant fraction of atmospheric pollution. Pollution is a continuing hazard to life and property on Earth and in space.

Combustion reactions release heat. Under gravity's influence, heat release during combustion causes a convective 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 allays. 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 are 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.

The Low-Temperature Microgravity Physics program includes the study of critical phenomena, low-temperature physics and other phenomena for which the space environment can make possible measurement of physical constants with levels of accuracy that challenge the 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.

Center and Contractor Support

The MSFC is the lead center for the materials science and biotechnology portions of the program. The JSC contributes to the biotechnology research program by conducting research in the cell culturing area. The Lewis Research Center (LeRC) has the lead for the fluid physics and the combustion science disciplines. The Jet Propulsion Laboratory (JPL) is responsible for the low-temperature physics and gravitational physics portion of the program. Contractors are utilized for science support at the Centers and *are* responsible for understanding and monitoring certain investigators science. They also assist the external scientists in the utilization of unique facilities at the centers required to carry out some of the low gravity experimentation.

MEASURES OF PERFORMANCE

	FY 1995	FY 1996	FY 1997
Number of Principle Investigators supported	242	260	290
Number of Co-Investigators supported [ground and flight)	286	300	330
Number of Graduate Students supported (flight and ground)	500	540	600
Number of Refereed Publications (flight and ground)	1,080	1,200	1,320

Complete 19 peer-reviewed studies in Biotechnology -- Sept. 1996	A summaxy 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 durlng 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 summaxy 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 Plan: Sept. 1995 Actual: Sept. 1995	A summaxy 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 far FY 1995.
Complete 50 peer-reviewed studies in Materials Science --Sept. 1996	A summaxy assessment of the results of these studies, which include electronic and photonic materials, glasses and ceramics. and metals and allays, will be included in the Annual Program Task and Bibliography for NASA Technical Memorandum FY 1996.

Complete 5 peer-reviewed ATD projects Plan: Sept. 1995 Revised: May 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 1995. Note: FY 1995-96 ATD project results have been combined.
Complete 5 peer-reviewed ATD projects Plan Sept. 1996 Revised: May1996	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 -- Microgravity Science Research and Analysis

In FY 1995, NASA received the largest annual volume of microgravity research proposals to date. The fluid physics and materials science disciplines released their second announcements (the first for each was released in August 1991), and the combustion science discipline released its third. NASA received over 700 proposals in response to these NRA's. To strengthen the ability of NASA Field Centers to support 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 began in FY 1995 with the additional funding provided for the NASA/National Institutes of Health cooperative activity, produced large growth of the microgravity tissue culture program. Two proposals from research teams for innovative multidisciplinary approaches to biotechnology research were funded at approximately $1 million each in FY 1995.

The FY 1996 request accommodates support of the selection from the 1994 fluid physics. materials science, and combustion science NASA Research Announcements. Low-temperature physics is soliciting proposals through the fluid physics NRA. As these disciplines enter a period of consolidation following vigorous growth in the early 1990's. NASA plans only modest budget increases that will allow for discipline maturation. The investigations currently supported 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, which will be accommodated through the FY 1997 budget request.

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 from 236 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.

The newly-outfitted DC-9 aircraft, operated by NASA's Lewis Research Center, began operations in late July 1995. This aircraft serves as an airborne research facility for microgravity science. The microgravity environment is a tool which allows scientists to temporarily minimize the effects of gravity on chemical, physical and biological processes and phenomena which in turn can provlde fundamental insight and understanding into these processes.

The first of three planned sounding rocket tests of the Spread Across Liquids experiment was successfully launched at White Sands Missile Range on November 22, 1994. The experiment is an investigation of the flame spread characteristics across a deep pool of combustible liquid in a microgravity environment. The second Spread Across Liquids Experiment was conducted very successfully on August 28th. A third launch is planned for March 1996.

The Biotechnology program saw significant growth in FY 1995, as 47 new investigators were selected for multi-year support. including two multi-disciplinary projects in three-dimensional tissue culturing. NRAs for fluid physics. materials science and combustion science were released in early FY 1995 with selections planned for early FY 1996.

BASIS OF FY 1997 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE FLIGHT PROGRAM

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Flight experiments program	74,000	76,300	71,700
NASA/Mir research program	11,300	8.700	6.800
Space station utilization program	11,800	17,800	32,200
(Construction of facilities - microgravity development complex)	(--)	(3,000)	(--)
To	97.100	102.800	110.700

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 Me 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 Mir Space Station. and the ISS 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 Mir Space Station to mitigate risk in scientiflc, technological. logistical, and operational planning. The objective of the Microgravity Science Flight program is to provide flight experiment opportunities for a range of scientiflc investigators in the areas of biotechnology, combustion science, 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. (See Microgravity Sciences Research and Analysis section for a brief description of these disciplines.) 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 Mir Space Station. and the ISS. The experiment apparatus ranges from small hand-held single experiments to multi-rack facility-class experiment hardware accommodating several investigators. The program includes selection, definition. and development, in-flight operational support. and data analysis/archiving 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 peer-reviewed science requirements. The flight program develops experiments, supports science operations, and analyzes flight gathered data and samples in all the major microgravity disciplines. The Flight Experiments program also fosters cooperative activities with other organizations to combine the research goals of those organizations to foster results from flight experiments which have previously eluded researchers on Earth.

The NMRP 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 Space Station users so that the station can be a unique laboratory for the U.S. scientific and technology community. The utilization program will support the development of flight hardware, the funding of U.S. principal Investigators, ground-based facilities, and science operations in the biotechnology, combustion science, 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.

Center and International Support for Flight Programs

Both the fluid science and combustion science programs are led by the LeRC, with contractor support from the NYMA and Analex Corporations. The materials science and protein crystal growth programs are led by the MSFC with support from Teledyne-Brown Engineering. The low-temperature fundamental physics and gravitational physics programs are led by the JPL. The cell and tissue culture program is lead by the JSC. with contractor support from Krug Life Sciences Corporation.

ESA developed the Spacelab module that is used in the U.S. Microgravity Laboratory (USML) series, LMS, and Microgravity Science Laboratory (MSL) missions. In addition, our international partners developed nearly all of the experiment apparatus that flew on International Microgravity Lab-2 (IML-2) and the equipment was shared by both international and U.S. investigators.

The Spacelab glovebox that flew 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 used 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 was 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 M S L 1 with U.S. and Japanese investigators.

The 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.

MEASURES OF PERFORMANCE-Shuttle Missions

	FY 1995	FY 1996	FY 1997
Number of Principle Investigators supported	34	40	40
Number of Co-Investigators supported	included under Research and Analysis		
Number of Investigators with on-orbit experiments	18	23	23

USML-2 Launch Plan: 4th Qtr FY 1995 Actual: 1st Qtr FY 1996	USML-2 focused on the physics of crystallization, fluid dynamics and biotechnology. Investigations continued from the highly successful USML 1 mission (6/92) as well as new investigations chosen since that time.
USMP-3 Launch--2nd Qtr FY 1996	The USMP-3 mission will focus on experlments in Microgravity Materials Science.
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.

MEASURES OF PERFORMANCE
Mir Missions

Spacelab Mir (SL-M) Launch
Plan: 3rd Qtr FY 1995
Actual: 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. This is an opportunity to reduce the technical risk associated with construction and operation of the ISS. 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. 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.

NASA/Mir 2 Launch
Plan: 1st Qtr FY 1996
Actual: 1st Qtr FY 1996

NASA/Mir 3 Launch -- 2nd Qtr FY 1996

NASA/Mir 4 Launch -- 4th Qtr FY 1996

NASA/Mir-5 Launch -- 1st Qtr FY 1997

NASA/Mir-6 Launch -- 3rd Qtr FY 1997

NASA/Mir-7 Launch -- 4th Qtr FY 1997

These missions will focus on expanding the current Shuttle-based research program and provide a transition to long-duration missions on the ISS. Their objectives are to: (1) learn to work with our Russian partners: (2) reduce scientific risk and enhance long duration experiment performance and science utilization for the ISS; (3) conduct combined international space operations and joint space technology demonstrations: and (4) provide early opportunities for extended scientific, technologic and engineering research and testing.

ACCOMPLISHMENTS AND PLANS

Flight Experiments Program

During October 1995, the program supported the reflight of the United States Microgravity Laboratory (USML-2), which focused on materials science, fluid physics and biotechnology. The USML-2 mission was outfitted with 14 microgravity research facilities containing 17 experiments and Seven glovebox investigations which were brought together from government, academia, and private industry.

In the field of Biotechnology. USML-2 used advanced technologies to fly over 1000 protein samples, more than any previous mission. Investigators processed the samples to grow high quality protein crystals for analysis on return to Earth. Previous Space Shuttle missions have unequivocally demonstrated that space-grown crystals can provide superior data for designing new drugs. NASA researchers have already used Space Shuttle missions to produce protein crystals for research into a variety of clinical conditions including diabetes, emphysema, and immune system disorders.

Fluid physicists used the low-gravity environment of the Space Shuttle to study the theoretical foundations of the behavior of liquids and gases. USML-2 included 14 co-investigators in the field of fluid physics. One experiment takes advantage of the low-gravity environment to create a physical model of large scale fluid flows like the flows that create the Earth's weather. previous Space Shuttle missions have used this technique to produce evidence of fluid instabilities previously unpredicted by existing computer models of the Earth's atmosphere.

Materials scientists used USML-2's Crystal Growth Furnace (CGF) to explore theoretical models of (inorganic) semiconductor crystal formation. The low-gravity environment of space provides scientists with unique new data that may enable them to improve production processes back on Earth. For example. Dr. David Larson's (SUNY at Stonybrook) experiment used the CGF to produce cadmium zinc telluride crystals in microgravity. In doing so. he can demonstrate the effects of gravity on the generation of structural defects in the crystal system, and using this information. improve crystal growth technology on Earth.

Additional flight activities in FY 1995 were conducted aboard the Space Shuttle and in the sounding rocket programs. On the Shuttle flight in November 1994, two related Protein Crystal Growth experiments were flown to continue research into the structure of proteins and other macromolecules such as viruses. They were the Crystal Observation System, housed in a Thermal Enclosure System and the Vapor Diffusion Apparatus. housed in a single-locker Thermal Enclosures. In addition to using the low-gravity of orbit to grow high-quality protein crystals for structural analysis, the experlments are helping to develop technologies and methods to improve the protein crystallization process on Earth. as well as in space. In support of these experiments, the Space Acceleration Measurement System was flown aboard the Space Shuttle, collecting and recording data characterizing the microgravity environment in the Shuttle middeck and *again* aboard the Mir.

The major FY 1996 efforts in Microgravity Science and Applications Flight Experiments *Program are* focused on the USMP-3 Spacelab and LMS missions. USMP-3 includes the same complement of experiment facilities as USMP-2: three solidification furnaces, each of which is designed to examine a different type of crystal growth. and a fluids facility. While the majority of the hardware is the same. the scientific research is new. Principal investigators have used the data from USMP-2 to redesign experiments to probe more deeply into phenomena that yielded so many scientific insights.

Research aboard the LMS mission in biotechnology, fluid physics, and materials science will allow U.S. investigators to use instruments developed by ESA, broadening the basis for international cooperation in space research. The LMS mission will be the first to fly the ESA Advanced Gradient Heating Furnace (AGHF), a new furnace facility of significant interest to the U.S. science community available to NASA through international cooperation. The AGHF will be used by NASA to conduct two materials science investigations 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 NASA investigations. as well

as experiments sponsored by ESA. NASA protein crystal growth project will conduct two new types of experiments on the 16-day mission.

In FY 1996, funding is required to modify and expand the existing 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.

Durlng FY 1997, the major efforts in the program will be focused on the MSL mission and three flights of the NMRP (NASA/Mir 5, NASA/Mir 6, and NASA/Mir 7). The MSL mission is currently manifested to fly in the third quarter of FY 1997. The mission will focus on investigations leading to the space station era in the disciplines of combustion science, fluid physics, protein crystal growth. and biotechnology.

Advanced Technology Development

In May 1995. four new projects were selected for funding in FY 1996 during the ATD Annual Review. Projects selected include: 1) Development of Low-Temperature Magnetostrictive Valves, Heat Switches and Smart Actuators for Microgravity Applications: 2) Compact Fiber Optic Surface Fluctuation Spectrometer; 3) Space Bioreactor Product Recovery System: and 4) Passive Free-Vortex Two Phase Separator. The solicitation of FY 1997 ATD concept papers took place in October 1995. These are currently under review, the selection of the papers for full proposals will take place in February 1996. and the final selection of proposals for FY 1997 again, in May 1996. during the Annual ATD Program Review.

NASA/NIH Program

The Microgravity program's cooperative effort with the National Institute of Child Health and Human Development to transfer NASA's bioreactor technology so that it can be used in the area of AIDS research began last fall. Researchers are using cultures of the human tonsil, lung, adenoid, and lymph node to assess the infectivity of the HIV virus on the tissues.

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.

Two multidisciplinary research centers are supported: Massachusetts Institute of Technology, Cambridge and the Wistar Institute, Philadelphia. These Centers expand the pace of technology transfer in the biotechnology areas begun under the NASA-NIH inter-agency agreement. Through NASA-NIH cooperation, NASA has funded approximately 28 research proposals. It has also supported

NIH approved researchers to test tissue samples in NASA bioreactors at JSC. This has proven to be a very important undertaking in getting researchers to test NASA technology and in gaining acceptance in the larger biomedical community.

NASA is currently working with the National Eye Institute to transfer NASA technology. This technology involves the use of laser light scattering to detect early signs of the onset of cataract formation. Discussions with managers from the National Eye Institute have led to the decision to proceed with development of a prototype diagnostic tool. After successful demonstration, the National Eye Institute is interested in obtaining the technology for use in a large scale clinical trail.

NASA is also collaborating with researchers at the National Eye Institute using protein crystal growth technology to determine the structures of important proteins related to the signal pathway for sight. This is a joint program between NASA. NIH, and Eli Lilly.

NASA/Mir Research Program

The first Space Shuttle docking mission with Mir took place in FY 1995. The Space Acceleration Measurement System was flown aboard the Mir collecting and recording data characterizing the microgravity environment. The remainder of the microgravity experiment apparatus planned for Mir will be delivered to Russia for installation in the Priroda module (March 1996) and subsequent Shuttle flights. This microgravity hardware includes the Glovebox, the Microgravity Isolation Mount (MIM) (in collaboration with Canada), and biotechnology hardware to support protein crystal growth and tissue culture growth.

FY 1996 activities associated with three flights of the NASA/Mir Phase I Research Program (NASA/Mir 2, NASA/Mir 3. and NASA/Mir 4), will include providing continuing research, experiment hardware. and mission management support of operation. In FY 1997, NASA/Mir-5,6 and 7 will further the objectives of the NMRP.

Space Station Utilization Program

The program consists of planning and integration activities, developing operations support procedures, and developing experiment unique research hardware for the International Space Station. The first major consolidated operations and utilization plan, developed using inputs from microgravity hardware developers and planners, were planned for assembly in FY 1995 and further refined in FY 1996. To prepare for microgravity operations on the ISS, 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, LeRC supported several microgravity experiments on two Space Shuttle missions and on the Mir Space Station. In FY 1996, LeRC will continue to operationally support experiments on the Space Shuttle and conduct a telescience demonstration. As the operational era of the ISS moves closer, the program focus will shift toward experiment development and planning with specific emphasis in the combustion and fluids disciplines.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACE SHUTTLE/SPACELAB MISSION MANAGEMENT AND INTEGRATION

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Space shuttle/spacelab mission management and integration	102.300	77,600	54,400

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 scientific. technological, and commercial user advocacy and coordination of requirements for the next genemtion 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, 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 ISS program to achieve greater efficiencies.

Center and Contractor Support

The principal NASA Centers which conduct activities in support of this program are the JSC. the KSC, and the MSFC. In FY 1997, JSC will provide the analytical integration and operations level project management support for the remaining NMRP missions, and the Neurolab mission scheduled to be launched in the second quarter of FY 1998. The KSC will provide the physical hardware science payload integration project management support for the NASA science payloads on the Microgravity Science Laboratory (MSL-1) flight. scheduled for launch during the third quarter of FY 1997. MSFC will provide the analytical integration and operations level project management support for the MSL-1 mission to be launched in FY 1997, and the United States Microgravity Payload (USMP)-4, to be launched in the first quarter of FY 1998. NASA Headquarters will provide program coordination for the second flights of the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere Shuttle Pallet Satellite (CRISTA-SPAS-2)and the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer Shuttle Pallet Satellite (OFWEUS-SPAS-2)missions, both scheduled for launch in FY 1997.

In FY 1997, the primary contractors that will be supporting the program at the Centers are: Lockheed-Martin at JSC; the McDonnell Douglas Corporation's Payloads Ground Operations Contract (PGOC) at the KSC; and Teledyne-Brown Engineering at MSFC. At JSC. Lockheed-Martin 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 and the number of middeck missions successfully flown as scheduled and the successful accomplishment of the science payload objectives. For the missions conducted in FY 1995, mission management performance was highly successful:

	FY 1995	FY 1996	FY 1997
Spacelab Missions	3	3	3
Mir Missions	1	3	3
Middecks/Small Payloads	16	8	5

SRL-2 Launch
Plan: 1st Qtr FY 1995
Actual: 1st Qtr FY 1995

This Shuttle Radar Laboratory mission collected data which will be used to improve our understanding of the Earth's environment, including the global carbon cycle, the water cycle, climatic and geologic processes, and Ocean circulation and air-sea interactions. An additional objective was to determine the ability to perform slight maneuvers to fine tune the Shuttle's orbit to intersect the track of the SRL 1 mission and support a space borne interferometry set. This would allow scientists to make measurements with the radar equipment and develop a three dimensional comparison of environmental changes during the six months separating SRL-1 and SRL-2. The mission was successfully conducted in the flrst quarter of the fiscal year.

ATLAS-3/CRISTA-SPAS-1 Launch
Plan: 1st Qtr FY 1995
Actual: 1st Qtr FY 1995

The third flight of the Atmospheric Laboratory for Applications and Science (Atlas-3)/First Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite (CRISTA-SPAS-1) successfully collected temperature and trace species data describing the state of Earth's middle atmosphere and measured the energy input from the Sun to the Earth system. The mission was successfully completed in the flrst quarter of the fiscal year.

Astro-2 Launch
Plan: 2nd Qtr FY 1995
Actual: 2nd Qtr FY 1995

This Spacelab pallet mission was a reflight of the ultraviolet portion of the Astro-1 astrophysics Spacelab payload, which flew in December 1990. It consisted of three experiments which were conducted by three separate and complementary ultra-violet telescopes. The mission was successfully conducted in the second quarter of the fiscal year.

Spacelab Mir (SL-M) Launch
Plan: 3rd Qtr FY 1995
Actual: 3rd Qtr FY 1995

This Spacelab module mission offered an unique opportunity to perform research aboard the Space Shuttle and the Russian Mir space station (while the two were docked together). This was the first time in twenty years since Apollo-Soyuz that U.S. and Russian spacecraft rendezvoused and docked, The research performed was in the fields of life sciences and microgravity science. The mission allowed for a better understanding of Russian medical monitoring, countermeasures and operational medicine programs, and long duration crew monitoring. Important insight into space station operations was gained through the joint operations. This mission was launched on schedule in the third quarter of the fiscal year and was highly successful in achieving its scientific goals.

USML-2 Launch Plan: 4th Qtr FY 1995 Actual: 1st Qtr FY 1996	The objectives of this Spacelab module mission were 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 were baselined for this mission. as well as seven additional U.S. investigations conducted in the USA52 Glovebox facility provided by the European Space Agency in a quid pro quo arrangement. This mission was successfully conducted in the flrst quarter of FY 1996. The mission's launch was delayed from the previously scheduled fourth quarter of FY 1995 due to Shuttle program considerations and weather problems.

The missions to be conducted in FY 1996 and FY 1997 are as follows:

NASA/Mir 2 Launch Plan: 1st Qtr FY 1996 Actual: 1st Qtr FY 1996	A docking module extension was attached to the Mir and will be used by the Shuttle for the remainder of the NMRP missions. Logistics and resupply for the U.S. experiments was accomplished ahead of plan due to efficiencies ('Lessons Learned") implemented as a result of the prior Shuttle/Mir mission experience. The Phase I Program is proceeding on plan. A database is being developed to transition the Phase I 'Lessons Learned" into the Phase II/III Space Station Program. The U.S. science for the remainder of the Phase I Program will be baselined by the end second quarter. This mission was launched on schedule and was highly successful in the achievement of its scientific goals.
USMP-3 Launch Plan: 2nd Qtr FY 1998 Actual: 2nd Qtr FY 1996	This USMP-3 mission performed 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	The LMS 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	Spacehab mission management and integration functions for these two module flights will be performed by Spacehab, Incorporated. 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 the International Space Station. A multi-disciplined joint U.S./RSA research program will be conducted on a continuous basis on board Mir during this period and beginning on Flight 3 NASA will have a U.S. astronaut on board Mir.
OFWEUS-SPAS 2 Launch 1st Qtr FY 1997	The second flight of the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer Shuttle Pallet Satellite (OFWEUS-SPAS-2) is an astronomical telescope for observations at very short wavelengths in two spectral ranges, the far ultraviolet (FUV) and the extreme ultraviolet (EUV). These spectrometers are mounted on the German built deployable/retrievable ——0-SPAS carrier.
M S L l Launch-- 3rd Qtr FY 1997	The M S L 1 will focus on microgravity combustion and international research in microgravity materials science. Three new microgravity combustion experiments will use two new, large research facilities constructed for this mission.
CRISTA-SPAS 2 Launch 4th Qtr FY 1997	The second flight of the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere Shuttle Pallet System (CRISTA-SPAS-2) is a set of spectrometers which measure the constituents of Earth's middle atmosphere. These spectrometers are mounted on the German built deployable/retrievable ASTRO-SPAS carrier.
NASA/Mir 5 Launch -- 1st Qtr, FY 1997 NASA/Mir 6 Launch -- 3rd Qtr, FY 1997 NASA/Mir 7 Launch -- 4th Qtr, FY 1997 NASA/Mir-8 Launch -- 2nd Qtr, FY 1998 NASA/Mir-9 Launch -- 3rd Qtr, FY 1998	Spacehab mission management and integration functions for module Flights 5 and 6 will be performed by Spacehab. Incorporated. 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 prepamtion for ISS. A multi-disciplined joint U.S./RSA research program will be conducted on a continuous basis on board Mir during this period. and NASA will have a U.S. astronaut on board Mir throughout the period.

Flight Experiments Program

In FY 1995, the Space Shuttle/Spacelab Mission Management and Integration program successfully managed four Shuttle missions whose accomplishments are described below: the second night of the Space Radar Laboratory (SRL-2), the third flight of the Atmospheric Laboratory for Applications and Science (ATLAS-3). the second flight of the Astronomy mission (Astro-2), and the Spacelab Mir (SL-M), the first of the nine-flight Phase I NMRP. Commencing with the S L M mission, NASA is conducting continuous on-orbit research aboard the Mir with United States and Russian astronauts. In addition to the four Shuttle missions, the mission management organization supported the flights of 13 smaller middeck class science payloads sponsored both by NASA and other government agencies and provided program management oversight to the very successful flight of the CRISTA-SPAS1 and the Shuttle Solar Backscatter Ultraviolet (SSBUV) experiment, both of which flew on the ATLAS-3 mission.

SRL-2 was completed at the beginning of the first quarter of the fiscal year. The highlight of the SRL-2 mission was the ability to perform slight maneuvers to fine tune the Shuttle's orbit to intersect the track of the SRL-1 mission and support a spaceborne interferometry set. This allowed scientists to make nearly identical measurements with the radar equipment and develop a three dimensional comparison of environmental changes during the six months separating SRL-1 and SRL-2.

ATLAS-3/CRISTA-SPAS-1/SSBUV was successfully completed during the first quarter of the fiscal year. All primary and secondary ATLAS-3/CRISTA-SPAS-1/SSBUV mission objectives were attained. The ATLAS-3/CRISTA-SPAS-1/SSBUV instruments successfully collected temperature and trace species data describing the state of Earth's middle atmosphere and measured the energy input from the Sun to the Earth system. The mission also provided highly calibrated measurements of stratospheric trace constituent composition and solar irradiance for related NASA and National Oceanic and Atmospheric Administration (NOAA) programs. The CRISTA-SPAS-1 satellite was deployed, operated, and retrieved. and its instruments explored the variability of the atmosphere and provided measurements which complemented the NASA payload science objectives.

Astro-2 was successfully completed during the second quarter of the fiscal year and was an outstanding achievement. The amount of scientific data acquired exceeded pre-mission expectations. Of special significance was the success of the Astro-2 World Wide Web program. This notable step forward allowed the public to follow the progress of the mission in near-real time. Over 200,000 individuals from 57 countries accessed the program over 2.6 million times. In view of the extremely positive response from the public. all future OLMSA Shuttle missions will be available through the Internet.

NASA/Mir Research Program

Significant accomplishments have also occurred in the NMRP durlng FY 1995. The completion of a number of significant, highly-successful technical and management interface meetings between NASA and the Russian Space Agency have resulted in plans and agreements initiating the joint research which is now in full scale operation on Mir. These accomplishments were followed by the S L M mission during the third quarter of the fiscal year. S L M was the first of the nine Phase I docking missions to the Russian

Mir Space Station. It culminated and highlighted a 116-day stay on the Mir by U.S. Astronaut Norm Thagard. During this period, Dr. Thagard and the two cosmonaut crew members conducted a wide range of research using both U.S. and Russian research hardware. The SGM mission provided the means to not only exchange the Mir crews on-orbit, but also carried to Mir additional equipment and supplies for continuing research activities. This historic mission was highly successful, returning to Earth with a substantial amount of scientific and environmental data and samples and specimens taken by the Mir crew during their stay on-orbit. One month before the launch of SLM. a Russian-built spacecraft (Spektr) outfitted with over 700 kg of NASA research hardware was launched from Russia and docked to the Mir station, providing a new pressurized laboratory in which NASA and Russian cooperative research will be conducted through mid-1998.

In FY 1995, the mission management organization also coordinated NASA's joint planning with the Department of Energy (DOE) concerning flights of the DOE-sponsored Alpha Magnetic Spectrometer (AMS), first on the Space Shuttle and later on the International Space Station. AMS, which will search for cosmic sources of antimatter and missing matter, is now a joint NASA/DOE program subsequent to an official interagency agreement signed on September 20, 1995. Anticipated in FY 1996 is the scheduled NASA Preliminary Design Review (PDR) for AMS.

In FY 1995. the mission management organization completed the second of two separate comprehensive reviews to streamline its operational procedures and achieve substantially lower costs for the mission management of the Spacelab programs. The Spacelab Re-Engineering Team, chartered in the fall of 1994 to review the program and to further streamline the processes and reduce the mission management budget, completed its task during the second quarter of FY 1995. The team's recommendations on improved processes have been accepted and implemented.

In the first quarter of FY 1996, two additional missions were successfully supported by the mission management organization: the second flight of the United States Microgravity Laboratory (USML-2), scheduled for flight during the last quarter of FY 1995, was delayed until the first quarter of FY 1996. due to Space Shuttle program considerations and inclement weather; and the NASA/Mir 2 mission, the second of the seven-flight NASA/Mir Research Program. USML-2 focused on materials science. fluid physics and biotechnology. The USML-2 mission was outfitted with 14 microgravity research facilities containing 17 experiments and Seven glove box investigations which were brought together from government. academia, and private industry. NASA/Mir 2 focused on transporting the Shuttle/Mir docking module.

Four additional missions are scheduled to be completed within the remaining months of FY 1996: USMP-3, LMS, and the third and fourth missions of the NMRP (NASA/Mir 3 and NASA/Mir 4). Continuous on-orbit research aboard the Mir is planned during FY 1996. In FY 1996, systems engineering efforts will continue to support methodologies for advocacy and coordination of U.S. research requirements and implementation of processes and tools for mission planning for U.S. payloads on future space platforms. primarily the phase 11 and 111 of the ISS.

During FY 1997, the mission management organization will provlde mission management support to the launch of four Shuffle missions which will conduct Life and Microgravity scientific research the MSL 1 mission and three flights of the NMRP (NASA/Mir 5. NASA/Mir 6 and NASA/Mir 7). The organization will also provlde program management oversight to the launch of two Shuttle missions which will conduct cooperative scientiflc research: ORFEUS-SPAS-2 and the reflight of CRISTA-SPAS-2. Activities

associated with the NMRP will also include providing continuing support of science operations on-board the Mir for the experiments. Mission management activities in support of missions to be launched in FY 1998 will also commence. In FY 1997, systems engineering efforts will continue to support methodologies for advocacy and coordination of U.S. research requirements and implementation of processes and tools for mission planning for US payloads on future space platforms, primarily the phase II and III of the ISS. Space Station planning and integration efforts will intensify as the First Element Launch date of the ISS approaches (December 1997). Spacelab-related activities will be sharply reduced in FY 1997, because the Spacelab modules fly for the last time in early 1998.

BASIS OF FY 997 FUNDING REQUIREMENT

AEROSPACE MEDICINE AND OCCUPATIONAL HEALTH

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Aerospace medicine and occupational health	6,600	8,000	*6,500*

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; 2) develop appropriate requirements for medical operations and medical research and 3) 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 and occupational health. The primary objective of the Aerospace Medicine and Occupational Health program is to maintain the health and productivity of astronauts, thus increasing the probability of success of space flight missions. The scope of work includes the refinement of standards and requirements for operational medicine in support of human 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 NASA lmowledge and technology achieved in 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 telemediclne 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 JSC is developing a telemedicine system at Star City, Russia to support the U.S. astronauts, night surgeons, and other personnel during the NASA/Mir Research Program (NMRP). In addition. JSC is developing a portable telemedicine capability, which will support medical operations activities for the International Space Station (ISS). The Russian Space Agency is providing some of the infrastructure in support of U.S. astronaut medical health monitoring for the NMRP missions.

The Space Biomedical Center for Research and Training, a collaboration between NASA and several Russian organizations, including the Russian Space Agency, the Ministry of Science and Technology Policy in Moscow, and the Institute of Biomedical Problems, has been established at the Moscow State University. This Center will focus on several activities including aerospace medicine training, medical education. telemedicine. and terrestrial applications of space technology from the Russian Space Program.

Center and Contractor Support

The JSC and Headquarters are the principal Centers involved in the Aerospace Medicine program. The ARC and LeRC are key Centers in the development of communications and computer technologies for the support of NASA's Spacebridge to Russia, an Internet based telemedicine testbed. The JSC will manage the telemedicine efforts in support of medical operations activities for the Human Space Flight Program. The ARC serves as the lead center for the telecommunications via the NASA Science Internet. Wright State University School of Medicine and the Texas Medical Center are the major contractors for the Aerospace Medicine program.

MEASURES OF PERFORMANCE

U.S./Russian Medical Policy Board Plan: 2nd Qtr, FY 1995 Actual: Under development	This establishes the U.S./Russian Medical Policy Board which validates medical fequirements. standards, protocols. and flight rules for all joint U.S./Russian missions.
First Draft ISS Medical Requirements Plan: 4th Qtr, FY 1995 Actual: 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 Telemedicine System Plan: 4th Qtr, FY 1995 Actual: 2nd Qtr, FY 1996	This effort establishes the configuration of the operational tele-medicine system and initiates its use in support of night 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 ISS mission activities.

Global Medical Network Scheduled: 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.

The Aerospace Medicine and Occupational Health program is in the process of redefining criteria for measuring performance. Possible criteria include: the conveyance of technology. protocols and procedures for terrestrial applications: and overall fitness of humans in space and their ability to do productive work by measuring the effectiveness of medical systems, countermeasures, and standards.

ACCOMPLISHMENTS AND PLANS

The JSC has developed a prototype portable telemedicine instrumentation pack (TIP) for use in support of medical operations for the International Space Station. The TIP has been configured to include several diagnostic instruments and video capability. Plans include the integration of a computer interface and inflight testing on the Shuttle in 1997. The Space Biomedical Center for Research and Training (SBC) was officially chartered by the Russian Government. The SBC will be located at the Moscow State University and will focus on a variety of disciplines. including aerospace medicine and telemedicine.

The program initiated the Spacebridge to Russia, an Internet-based, telemedicine testbed linking medical centers in the U.S. with several clinical sites in Moscow using multimedia workstations. Several Internet tools will be employed including the World Wide Web and video teleconferencing capability. Epidemiological studies evaluating long-term consequences of space flight and analog (medical) populations were continued.

A space medicine program is being initiated to focus on continuous improvement in medical requirements for spaceflight through the development of appropriate laboratory and diagnostic tests. This program will incorporate activities from several JSC programs including the Crew Health *Care* System for ISS, medical operations activities, and the Human Research Facility.

FY 1996 plans for the program include: 1) conducting Spacebridge to Russia, a telemedicine testbed using the Internet: 2) supporting development of the Pan American Health Organization and Global Health Network Internet systems for disaster response planning and for sharing preventative medicine and public health information; 3) developing a network of medical experts for all telemedical consultations for spaceflight mission support (e.g., flight crew or disaster recovery): 4) developing and inflight testing of the TIP: 5) continuing comprehensive risk assessment and review of medical requirements for space flight during long duration missions: 6) continuing the Space Medicine Program for 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; 7) providing operational medical support for Space Shuttle missions, support for NMRP, and the implementation of a comprehensive medical care! facility for the ISS: 8) establishing a Joint Medical Policy Board and developing joint medical operations requirements documents all the ISS partners: and 9) continuing the efforts of the SBC.

FY 1997 plans are to continue to provide operational medical support for the Space Shuttle and NASA/Mir missions and to conduct medical requirements reviews in preparation for the ISS era. It will continue to evaluate new technologies that will support these activities. and ensure appropriate systems are in place to enhance mission success. Activities at the SBC will continue. Support of the Space Medicine Program will continue to ensure the development of medical requirements and assessment of medical risks, establishment of priorities for medical research. and development medical flight policies in support of all US. spaceflight programs including Shuttle, NASA/Mir, the ISS. and future exploration missions.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACE STATION PAYLOAD FACILITIES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Space station payload facilities	90.500	133.500	187.100

PROGRAM GOALS

The International Space Station (ISS) will be the world's 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 scientific knowledge and to contribute new scientific discoveries for the benefit of the United States and to accelerate the rate at which it develops beneficial applications derived from long-term. 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 eight facilities and two projects: Human Research Facility (HRF); Gravltational Biology Facility (GBF); Centrifuge Facility (CF); Space Station Furnace Facility (SSFF); Fluids/Combustion Facility (FCF); Biotechnology Facility (BTF); Protein Crystal Growth Facility (PCGF); Low-Temperature Microgravity Physics Facility (LTMPF); the Risk Mitigation Project and the Expedite the Processing of Experiments to Space Station (EXPRESS) Rack Project.

The HFW will define and develop space flight research hardware to serve a number of closely related objectives. The HFW 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 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 will design, develop, and conduct on-orbit performance verification of two habitat holding systems, a two-and-a-half meter diameter centrifuge rotor. life sciences 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 such as the National Institutes of Health (NIH), the National Science Foundation (NSF), and NASA The working group represents the requirements of the science community to the facilities projects. helps the projects define requirements, review hardware design concepts, and directs the performance and review of tests to refine science requirements. The Ames Research Center (ARC)will lead the development of the GBF and the CF.

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 varlous 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.

In addition to the major facility-class payloads, NASA plans to *fly* smaller, less complex payloads on the ISS which will typically have more focused research objectives and shorter development time cycles. The EXPRESS 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 ISS.

Laboratory Support Equipment (LSE) is also under definition review for the Space Station in order to support Microgravity Sciences and other experiments. Six pieces of equipment are currently being reviewed. LeRC is reviewing the Film Locker. electro-magnetic shielded locker and the fluid handling tools. MSFC is reviewing the Video Camera, Digital Thermometer, and the Micro-Mass Measurement Device. Both Centers are currently reviewing requirements and cost estimates for LSE and plan to revise facility development based on more specific requirements definitions.

Contractor and Center Participation

The HRF development effort will be managed primarily as an in-house effort at JSC. but it will draw contractor support primarily from Lockheed-Martin and Krug Life Sciences. Lockheed-Martin 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 JSC. The GBF and the CF projects will rely upon procurement strategies that differ from that of the HRF, but these facilities too will rely heavily upon support contractors. The Bionetics Corporation will support science definition and development for the GBF and CF. but the two projects will each adopt their own hardware engineering and development strategies. Lockheed-Martin will support an in-house ARC development effort for the GBF. while the CF project anticipates that it will select and direct a prime contractor to develop the major CF hardware components in 1996. The BTF project is led by JSC. with contractor support from Krug Life Sciences Corporation. The FCF is led by the LeRC. with contractor support from the NYMA and Analex Corporations. The SSFF effort is led by the MSFC as an in-house effort.

External and International Cooperation

NASA is actively pursuing international participation the Space Station facility projects. For example, the GBF project has contacted the space agencies of Japan, Germany, and Canada to solicit their participation in the development of an aquatic habitat and insert. A multilateral users working group, consisting of representatives from all the major ISS participating countries, has agreed to principles for eliminating redundant flight hardware. NASA and the European Space Agency (ESA) have established a bilateral agreement to develop four flight copies of a -80° C freezer. 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. NASA will pursue other agreements of this sort in order to increase the science returns and the economies of the ISS program.

MEASURES OF PERFORMANCE

HRF Interim Design Review, Rack 1 2nd Qtr, FY 1996	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 3rd 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.
HRF System Flight Design Review, Rack 1 1st Qtr. 1997	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.
GBF Preliminary Design Review, Rack 1 4th 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 3rd Qtr, FY 1997	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.
Centrifuge Rotor and Idfe Sciences Glovebox Development Contract -- 3rd Qtr, FY 1996	Contract authority to proceed will initiate the design, development and testing of Centrifuge hardware.
The BTF program and schedule are currently under review.	
FCF Core System Conceptual Design Review Plan: 1st Qtr. FY 1995 Actual: 1Qtr, 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 - Plan: 1st Qtr, FY 1995 Actual:: 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 MSL-1 integrated with the initial payload and processed in preparation for launch in FY 1997.
SSFF Critical Design Review -- 4th Qtr FY 1997	This review verifies the suitability of the design in meeting the specified requirements and establishes its "built-to" project baseline. 90% of night drawings should be complete at this stage.
FCF Core System Preliminary Design Review 2nd Qtr, FY 1997	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.
FCF Fluids Module Preliminary Design Review 4th Qtr. FY 1997	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.

ACCOMPLISHMENTS AND PLANS

Human Research Facility

The HRF project considered various procurement and development strategies during FY 1995 and determined that existing Life Sciences flight hardware can support the project's research requirements adequately. The HRF activities will include modifications to existing flight hardware during FY 1996 and FY 1997. New hardware will also be developed, but it 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, Lockheed-Martin, for hardware engineering and development support.

Durlng FY 1995 and early FY 1996. the HRF project finalized its science requirements through the HRF's science working group. In FY 1996, the project to begin modifying and developing HRF precursor research equipment to fly on the last two NMRP missions. The project will develop procedures for conforming to Russian policies and procedures related to biomedical monitoring and countermeasures. The HRF project will also proceed with the development of Rack one hardware to support an FY 1999 launch. Beginning early in the second quarter of FY 1996, the HRF project will hold meetings with the international community to discuss sharing hardware development for racks one and two. NASA anticipates that sharing arrangements with the ISS international partners for HRF hardware development will yield efficiencies and minimize hardware redundancies. The HRF project has planned an interim design review for the Rack one system for the second quarter of FY 1996. It expects to conduct a system design review for rack one during the third quarter of FY 1996. During the first quarter of FY 1997. the HRF project expects to conduct a system level Anal design review.

As of FY 1996, the HRF project has assumed responsibility for the Crew Health Care Subsystem (CHeCS), under agreement with the International Space Station program office.which has provided requirements definition to this point. CHeCS will provide for medical care for the ISS crew following deployment of the U.S. Laboratory module in late 1998. and will provide medical care,

operational exercise, countermeasures and environmental monitoring aboard the ISS. By assuming the CHeCS responsibility, hardware commonality between CHeCS and the HRF will be evaluated, with the synergy between the two programs resulting in efficiencies and cost savings.

Gravitational Biology Facility

During FY 1995, the GBF focused on developing detailed system specifications for equipment and system-level designs for the project's space and ground segments. A rack level preliminary design review is scheduled for the fourth quarter of FY 1996, to be followed by a rack level critical design review during the third quarter of FY 1997. During FY 1996, GBF project activities will also focus on developing various habitats that will integrate into Rack one, e.g., incubator and cell culture units. Other GBF activities will include the development of habitat science evaluation hardware for testing by the science community. These science tests will evaluate science utility of the GBF habitat designs. The flrst complement of GBF hardware will launch to the ISS during FY 1999. Rack two will launch in FY 2002.

Centrifuge Facility

During FY 1996. the CF project will select a development contractor who will build the CF rotor and the life sciences glovebox. The project will continue in-house hardware development and test bedding, and it will proceed with science requirements definition. A rodent metabolism study now being performed by the Bioenvironmental research Laboratory at the University of Illinois at Urbana-Champaign will continue. as will the rodent acoustic tolerance testing being done at San Jose State University. Life sciences established a combined CF/GBF science working group durlng FY 1995 to conduct a variety of new studies in support of both the GBF and CF activities. The CF project expects to complete the facility-level preliminary design review during the first quarter of FY 1997, and the project will continue to support science studies to evaluate and improve upon hardware designs and configurations. The centrifuge rotor, life sciences glovebox, and holding rack are now scheduled to launch to the ISS during 2001.

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 was held in March 1995. In FY 1996, the BTF experiment control computer will 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 Critical Design Review is currently scheduled for the end of FY 1996, however the project schedule is currently being reevaluated.

Fluids/Combustion Facility

In FY 1994. the FCF completed Phase A studies on the fluids module. The precursor to the flrst facility combustion module entered the design and development phase to be prepared for flight on MSL l (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 and held its transition review in March 1995. The first international workshop to identify possible cooperative experiment module development in fluid physics and combustion science was held in April 1995. NASA conducted an internal assessment of the FCF in early 1995. An independent assessment of the facility was also held in April. NASA also developed a System Architecture Team to review the FCF concept following the direction to optimize the operational aspects of the design and to increase science output (datal. The combustion and fluids modules for the FCF will both hold their Requirements Definition Review in mid 1996. After successful completion of the review. the facility will proceed to the design and development phase. The preliminary design review is scheduled for FY 1997. The current launch readiness date for FCF and the first fluids module is the third quarter of 2000.

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 occurred in 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.

Risk Mitigation Project

In order to better understand and mitigate a number of potential risk factors for long-duration flight operations, during FY 1995 the Payload Facilities program initiated the development of ISS hardware items for use early in the ISS assembly phase for both operational health and human life sciences research. The hardware that is being developed includes a treadmill (with vibration isolation technology), a heart rate monitor, a blood pressure and ECG monitor, and a cycle ergometer. Some of this equipment will be located in the Russian modules in order to provide required capabilities to support permanent human presence prior to assembly of the U.S. laboratory module. The development of this equipment is planned for completion by the end of FY 1997, in time for early deployment during the ISS assembly phase.

EXPRESS Rack Project

In FY 1995, detailed design was completed and assembly and test is now 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. In FY 1996, testing and integration of the MSL1 EXPRESS rack will be completed, 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. In FY 1997, the MSL Spacelab mission will demonstrate

operations of science payloads on orbit using an EXPRESS rack. Fabrication and testing of the first EXPRESS rack to *fly* on the ISS will begin in order to support launch readiness for the first ISS utilization flight in FY 1999. EXPRESS rack interface simulators will be fabricated for use by EXPRESS payload developers.

Mission to
Planet Earth

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH | **MISSION TO PLANET EARTH**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	page Number
		(Thousand of Dollars)		
Earth observing system	574,100	535.300	585.700	SAT 3-6
Earth observing system data information system	220,600	241,200	261,100	SAT 3-21
Earth probes	81,600	46,000	47.100	SAT 3-24
Payload and instrument development	19,500	--	--	SAT 3-29
Applied research and data analysis	361,800	337,800	379.100	SAT 3-30
Global observations to benefit the environment	5,000	5,000	5,000	SAT 3-42
Advanced communications technology satellite	2,300	--	--	SAT 3-44
Launch services	62,200	107,100	124,100	SAT 3-45
Construction of facilities	17,000	17,000	--	SAT 3-47
(Earth system science building)	(17,000)	(17,000)	(--)	
To	1.344.100	1.289.400	1.402.100	

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996 (Thousands of Dollars)	FY 1997
Distribution of Program Amount by Installation			
Johnson Space Center	90	--	--
Kennedy Space Center	3,275	4,900	4,500
Marshall Space Flight Center	5.960	3,300	2,000
Stennis Space Center	155	100	--
Dryden Flight Research Center	--	2.200	2,700
Ames Research Center	40,643	39,788	13,200
Langley Research Center	25,803	12.505	8,187
Lewis Research Center	14.689	66,200	51,300
Goddard Space Flight Center	1,054,416	913,744	1,036,602
Jet Propulsion Laboratory	87,650	44,998	47,063
Headquarters	111.419	201.665	236.548
To	1.344.100	1.289.400	1.402.100

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 MTPE's 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 and analyzes data and disseminates these data, information. and scientific understanding throughout the world. Data, information. and knowledge 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 advanced 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 effort on global environment helps ensure a level playing field for enterprise. The MTPE program includes, on a fully reimbursable basis. technical and procurement support for the nation's civilian weather satellite system on behalf of the National Oceanic and Atmospheric Administration (NOAA).

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.

During 1995. NASA conducted a comprehensive review of the entire MTPE enterprise. The goal was to adopt an evolutionary approach to program planning which would enable: a focus on near-term science and associated applications: explicit provision for new technology infusion: reduction in life-cycle cost of EOS program: provision of new science opportunities through smaller, quicker and less expensive missions: and, closer participation with other Federal agencies (especially the NOM), commercial firms, and international partners.

The result of this review is an EOS which is lower in life-cycle cost, more flexible in implementation, and of greater utility to the science and commercial communities. We continue to refine this plan and seek the advice of the National Academy of Sciences (NAS) and other external groups as we progress. Our basic approach has been endorsed by the NAS Board on Sustainable Development. The details of this new approach to the program are discussed in the appropriate sections below.

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 1996. launch of the NASA Scatterometer and TOMS instrument on the Japanese Advanced Earth Observing System (ADEOS) spacecraft in FY 1996, and launch of the Tropical Rainfall

Measuring Mission (TRMM) in late FY 1997. The mission operations and data analysis program within MTPE will begin operations of the Earth probe satellites and processing of the data received from them in addition to maintaining activities for currently orbiting satellites, including TOPEX/Poseidon and UARS 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, preliminary design review will be held for PM-1 in FY 1997. Critical design reviews will be held for the SeaWinds spacecraft and Stratospheric Aerosol and Gas Experiment (SAGE-III) in FY 1996. Instruments for AM-1 and Landsat-7 will be delivered in FY 1997. The EOSDIS will release Version 1 in FY 1997. and prepare for the release of Version 2.

The EOS AM-1 will be launched in June 1998. This mission will provide key measurements that will significantly contribute to our understanding of the total Earth system. The AM-1 instrument complement will obtain information about the physical and radiative properties of clouds. air-land and air-sea exchanges of energy, carbon, and water, measurements of trace gases, and volcanology.

Landsat 7 will launched in September 1998. Landsat 7 will carry a single instrument, the Enhanced Thematic Mapper Plus, which will make high spatial resolution measurements of land surface and surrounding coastal regions. This mission will provide data continuity with previous Landsat measurements. Landsat data is used for global change research, regional environmental change studies, national security and other civil and commercial purposes.

The measurements to be made by these and other future MTPE missions as well as current on-orbit missions provide data products that are used extensively in the MTPE science program. The program encompasses over 1,700 scientific activities at universities, research laboratories. and government research organizations. These activities are providing an ever increasing scientific understanding of global environment and the effects of natural and human sources of change.

BASIS OF FY 1997 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
AM series	259.800	170.000	84,700
PM series	88,800	101,800	171,200
Chemistry	10,300	27,300	77,400
Special spacecraft	81,700	71,700	66,700
(Space station attached payload - SAGE III	(--)	(3,700)	(9,000)
New millennium program	1,000	10.000	10,000
Landat-7	77,400	78,800	73,900
Algorithm development.	55,100	75,700	101,800
To	574,100	535,300	585,700

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 data will be used to 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, Me-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 OR 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 (USGCRP) 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.

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 worlds decision makers have a common body of information that is credible and well understood. AM-1 includes instruments provided by Canada and Japan. and international partners contribute to several other key EOS missions. Within the special spacecraft program, flight of the Altimetry-Radar and Altimetry-Laser satellites, as well as SAGE-111, SeaWinds, Active Cavity Radiometer Irradiance Monitor (ACRIM), Solar Stellar Irradiance Comparison Experiment (SOLSTICE), and Clouds and Earth's Radiant Energy System (CERES) instruments will be accomplished with a combination of domestic dedicated spacecraft and international participation by Japan, Russia, as well as France, the United Kingdom, and other European countries.

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 multidisciplinary 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 **six** 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 Reviews (CDCR's) of the selected instruments and IWG Payload Panel recommendations on scientific 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 five-year life and each was to be replaced twice to provide a 15-yearmission. The budget runout through FY 2000 was $17 million.

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% to $8 billion. The EOS reassessment was completed in June 1992. satisfying the 30% 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(HIRIS) flight instrument. As a result of the rescoping process, EOS became recognized by NASA as a cost-driven program.

In the 1995 Congressional budget cycle, the EOS budget was reduced by $758.5 million through FY 2000. to $7,243.4 million, of which $131.3 million was due to a funding responsibility transfer. The EOS rebaselining effort conduct in 1994. with the following results. was reflected in the FY 1996 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. As another aspect of the rebaseling, the EOS science program was reorganized. The funding to support the activities of the EOS instrument investigators and interdisciplinary science investigators was moved to research and analysis. The science algorithm development and maintenance remains in the EOS budget.

During 1995. NASA conducted a comprehensive review of EOS to reshape mission planning to accomplish a number of interrelated objectives: substantially reduce EOS life-cycle costs while preserving the basic measurement set; provide now for technology infusion so that it will be available in time to be able to lower the cost of the second and third EOS series; provide new science opportunities through small satellites: and. adjust program management to an evolutionary approach.

This 'reshaping" exercise recognized that the first series already employs or advances the state-of-the-art in spacecraft and instruments. Even so, savings achieved in EOS Data and Infoxmation System (EOSDIS) implementation and other changes enable some savings and improvements in the first series. These include accelerating Laser Altimetry and ACRIM by one year, providing a

spacecraft for SOLSTICE (previously awaiting a flight of opportunity), and the explicit provision of funding within the EOS budget for new technology missions.

The second series relies upon technology development to reduce the size of instruments, and therefore the size of spacecraft required--cutting the total weight approximately in half for the multi-instrument missions. This should enable movement from medium class expendable launch vehicles (MELV's) in the first series to medium-light class ELVs (MLELV's) in the second series. when we expect these launch capabilities to be available. One key to the development of these advanced instruments is the NASA's New Millennium Program. in which NASA's programs for Mission to Planet Earth, Space Access and Technology, and Space Science, are engaged in demonstration flights of much smaller prototype component technologies.

The reshaped second series also provides an advanced Landsat-type instrument to be incorporated on EOS AM-2, saving the government the cost of a separate spacecraft and launch (approximately $325 million in the Landsat-7 program). The EOS PM-2 spacecraft can be substantially downsized if the National Polar-Orbiting Environmental Satellite, planned for launch in 2006, can incorporate an infrared sounder with adequate specifications and calibration. NASA will work with NOAA and the Department of Defense (DoD) over the next three years to find a way to do so. Downsizing the remaining EOS PM-2 instruments enables them to be flown on a small spacecraft. The second EOS Chemistry (CHEM) mission is planned to be split into two smaller missions: one for largely stratospheric measurements taken in a monitoring mode and one largely for tropospheric measurements taken in a process study mode. This sets the stage for even less expensive implementation of the third series. Autonomous operations will be adopted in the second series to further reduce the cost of ground operations.

The third EOS series is left relatively undefined to allow maximum flexibility for technology infusion and greater international and commercial participation to reduce the cost of completing the basic commitment to the EOS measurement set. By this point in the development program. the process for infusion of new technology from the New Millennium Program and other sources will be routine. Further advances in computing and network technology should continue to decrease Earth Observing System Data and Information System (EOSDIS) operations costs.

Within NASA, the Goddard Space Flight Center (GSFC) is responsible for development and operation of the MTPE 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-observing sources. An MTPE Office has been established within the Office of the Director at GSFC to provide overall management. guidance, and coordination of the MTPE 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 Lockheed Martin Astro Space (LMAS) 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 Tropical Rainfall Measuring Mission (TRMM) in 1997 and PM Series

spacecraft, and as a flight of opportunity), and Lockheed Martin Commercial Launch Services for the AM-1 Atlas Centaur/IIAS launch service. The Multi-Angle Imaging Spectrometer (MISR) instrument is being built in-house at the Jet Propulsion Laboratory (JPL). The Japanese will provide 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. The Earth Observing Scanning Polarimeter (EOSP) instrument for AM-2 will be built in-house at GSFC.

PM Series

The research focus of the PM series is 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 TRW for the common spacecraft to be used for PM-1 and Chemistry-1: Loral Infrared and Imaging Systems (LIRIS) and JPL for the Atmospheric Infrared Sounder (AIRS) instrument: and Aerojet General Corporation for the Advanced Microwave Sounding Unit (AMSU-A) instrument. We anticipate that the Japanese will be providing the Advanced Microwave Scanner Radiation (AMSR) instrument for the PM-1 spacecraft. We are currently negotiating with Brazil for provision of the Microwave Humidity Sounder (MHS).

Chemistry Series

The study area for the Chemistry (CHEM) series will be atmospheric chemical species and their transformations. The Tropospheric Emission Spectrometer (TES) and the Microwave Limb Sounder (MLS) instruments are planned to be built in-house at JPL. The Japanese will provide the Ozone Dynamics Ultraviolet Spectrometer (ODUS) instrument and Lockheed and Rutherford Appleton Lab/Oxford University in the United Kingdom will provide the High Resolution Dynamics Limb Sounder (HIRDLS) instrument for the CHEM-1 spacecraft.

special spacecraft

The special spacecraft will be designed to study atmospheric aerosols. ocean circulation. ice-sheet mass balance, cloud physics. atmospheric radiation properties. and solar irradiance. Ball Aerospace is responsible for developing SAGE-III that will fly on a Russian spacecraft in 1998 and on the Space Station in 2001 and will take advantage of both solar and lunar occultations to measure aerosol and gaseous constituents of the atmosphere. The Japanese will provide the Advanced Earth Observing System II (ADEOS II) spacecraft for the SeaWinds instrument. The first Altimetry Radar mission will be as follow-on to the TOPEX/Poseidon as a joint mission with the French Space Agency (CNES), with data provided to the U.S. Navy and NOM for operational purposes and the U.S. Navy. The Laser Altimetry mission is presently planned as a dedicated domestic mission. There remain a number of instruments in the program that are also identified as flights of opportunity (i.e. ACFUM, SOLSTICE. and CERES).

New Millennium Program

This budget reflects a commitment to develop new technology to meet the scientific needs of the next few decades and to reduce future EOS costs through focused technology demonstrations for Earth orbiting missions. Three Headquarters program officesare coordinating their program plans to do these missions. OMTPE has joined the Office of Space Science and the Office of Space Access and Technology in the New Millennium Program (NMP) in order to capitalize on common work from core technology development programs and specific spacecraft and instrument studies. The NMP project will identify and demonstrate advanced technologies that reduce cost or improve performance of all aspects of mission for the next century, (i.e., spacecraft, instruments and operations). The program objectives are to spawn "leap ahead" technology by applying the best capabilities available from several sources within the government, private industries and universities. These low cost, tightly controlled developments will take more risk in order to demonstrate the needed technology breakthroughs and thus reduce the risk of using that technology in future science missions. A series of workshops were conducted to inform other government agencies, industry. academia and non-profit research and development organizations and to solicit input for program implementation. Integrated Product Development Teams (IPDT) were established to coordinate a cooperative effort to identify. develop and deliver focused technologies to provide the needed capability. Missions will be selected based on their ability to meet the science needs of the future by innovative technology that would also decrease the cost and improve the overall efficiency of space flight missions.

Landsat

With the launch in 1998 of Landsat 7, substantially cloud-free, sun-lit land surface imagery for detecting and characterizing regional and global change will continue. The primary contractors are Lockheed Martin Astro Space (LMAS) for the Landsat-7 spacecraft, Hughes Santa Barbara Research Center (SBRC) for the Enhanced Thematic Mapper Plus (ETM+), and McDonnell Douglas for the Landsat-7 Delta 2 launch service. The Landsat 7 estimate includes funding for ground segment development. NOM will be responsible for operating the satellite and the United States Geological Survey (USGS) will archive the data.

MEASURES OF PERFORMANCE

Preliminary Design Reviews: 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 represent acceptable risk.

SeaWinds	
Plan:	May 1995
Accomplishment:	May 1995
SAGE III	
Accomplishment:	July 1995

PM-1 Plan/Current:	April 1997	Dependent on resolution of procurement protest
EOS Chemistry-1 Plan/Current:	March 1998	
critical Design Reviews:		**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.
AM- 1 Plan:	January 1995	
Accomplishment:	January 1995	
SeaWinds Plan:	December 1995	Due to scheduling conflicts, the CDR date was changed
Accomplishment:	January 1996	
Landsat-7 Plan:	September 1995	Due to scheduling conflicts the CDR date was changed
Accomplishment:	October 1995	
SAGE III Plan/Current:	July 1996	
PM-1 Plan/Current:	April 1998	Dependent on resolution of procurement protest
EOS Chemistry-1 Plan/Current:	June 1999	
Instruments Delivered:		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.

Landsat-7
Plan/Current: December 1996

AM-1 Last Instrument
Plan/Current: February 1997

Aerosol SAGE-111 (Russian)
Plan/Current: December 1997

SeaWinds
Plan/Current: March 1998

PM-1 Last Instrument
Plan/Current: December 1998

Algorithm Development (Version **2):**

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.

EOS AM-1
Plan: June 1997
Current: February 1998

Revised date reflects the last instrument development completion

Aerosol SAGE-111 (Russian)
Plan/Current: December 1997

Altimetry Radar-1
Plan/Current: December 1998

EOS PM-1
Plan: December 1999
Current: July **2000**

Revised date reflects the last instrument development completion

Chemistry-1
Plan/Current: December **200**1

Altimetry Laser-1
Plan/Current: July **2002**

Launch Readiness Dates:	Verifies that the system elements constructed for use. and the *existing* support elements, such as launch site, space vehicle and booster, are ready for launch.
Initial NMP flight demonstration Current: 1998	
AM-1 Plan/Current: June 1998	
Landsat-7 Plan/Current: December 1998	
Aerosol SAGE-111 (Russian) Plan/Current: December 1998	
Altimetry Radar-1 Plan/Current: December 1999	
PM-1 Plan/Current: December 2000	Dependent on resolution of procurement protest.
Chemistry-1 Plan/Current: December 2002	
Altimetry Laser-1 Plan: July 2003 Current: July 2002	Launch accelerated in recent EOS reshape
SOLSTICE Current: December *2002* Accomplishment:	

ACCOMPLISHMENTS AND PLANS

AM Series

Following the Critical Design Review (CDR) and External Independent Readiness Review (EIRR) in January 1995, emphasis in the AM-1 development program was shifted to fabrication and assembly of subsystem engineering models and the build-up of

subsystem flight models. Testing of engineering model subsystems has proceeded with no significant problems. Fabrication and assembly of the spacecraft primary structure is under way.

Good progress was made on all five AM-1 instruments during FY 1995. The MODIS instrument completed its engineering model testing in May, and fabrication and assembly of the protoflight model is under way. The MISR CDR was completed in December 1994, and testing of the engineering model is nearing completion. The CERES engineering model is complete, and the protoflight model to be flown on TRMM was delivered in October 1995. Fabrication and assembly of the CERES flight model 1 (for AM-1) is under way. The Japanese ASTER radiometer CDR was completed in February 1995. Testing of the ASTER integrated engineering model is complete. The Canadian MOPITT CDR was completed in July 1995, and development and testing of the engineering model is proceeding.

Fabrication and assembly of all AM-1 spacecraft subsystems (except propulsion) will be completed in FY 1996. The propulsion subsystem will be completed in the first quarter of FY 1997. Spacecraft integration and test will begin and continue throughout FY 1996 and into the first half of FY 1997. Testing of the fully integrated ASTER engineering model was completed in the first quarter of FY 1996. Fabrication and assembly of all AM-1 instruments (ASTER, CERES, MISR MODIS, and MOPITT) will be completed in FY 1996. Integration and test of all instruments will begin, with deliveries scheduled through the first half of FY 1997. The "Beta" version of the AM-1 instrument science software will be delivered in the second quarter of FY 1996.

Integration and test of the AM-1 spacecraft will be completed in mid-FY 1997. Version 1 of the science software will be delivered in the second quarter of FY 1997. The second EIRR will be held prior to the start of environmental testing of AM-1 (with all instruments integrated onto the spacecraft). Environmental testing will begin in mid-FY 1997 and continue into FY 1998. in preparation for the launch of AM-1 in June 1998.

PM Series

The request for proposals (RFP) for the common spacecraft to provide medium-size platforms for the PM-1 and Chemistry-1 flights was released in September 1994. The planned procurement includes two Arm-buy and two optional spacecraft. In September 1995. TRW was selected for the common spacecraft contract. After protests were filed with the General Accounting Office (GAO), a stop work order was issued to TRW.

The AIRS. AMSU. CERES, and MODIS PM-1 instruments remain on schedule for a December 2000 launch. All issues identifled in the January AIRS PDR were closed out by the end of FY 1995, and the CDR is scheduled for February 1997. The AMSU PDR was completed in September 1994. Because the build of AMSU instruments for the operational weather satellites was added to the EOS AMSU contract, the AMSU CDR has been delayed from mid FY 1995 to April 1996. Development of the CERES and MODIS instruments for PM-1 are proceeding on schedule in synchronization with the AM-1 program.

The search for an alternative to the MHS instrument, which was originally to be provided by EUMETSAT, is continuing. The Brazilian space agency is currently exploring partnership arrangements for providing an MHS instrument.

The European Space Agency (ESA) indicated recently that it would not be able to commit to providing a Multifrequency Imaging Microwave Radiometer (MIMR) instrument for the PM-1 spacecraft. NASA is therefore pursuing Japan's offer to provide an AMSR instrument. The Japanese engineers and the PM-1 project at GSFC are performing accommodation studies. An in-house build of a PM Microwave Imager (PMMI) under evaluated as a backup, although this effort will be dropped if an agreement with the Japanese on AMSR can be implemented.

Because of the stop work order on TRW, the PM-1 spacecraft System Concept Review (SCR) has been delayed. The CDR for the PM-1 AMSU instrument will be held the third quarter of FY 1996. The AIRS and AMSR CDR's are scheduled for FY 1997 and FY 1998 respectively. The CDR's for CERES and MODIS have already been completed. The PM-1 flight instruments (AIRS. AMSU. AMSR, CERES, and MODIS) will be in various stages of fabrication, assembly, integration, and test throughout FY 1996.

Integration and test of the AIRS engineering model will begin in FY 1997 with dellvery scheduled for the fourth quarter of FY 1997. Fabrication and assembly of the AIRS protoflight model will continue throughout FY 1997. Fabrication and assembly of the remaining PM-1 flight instruments (AMSU, AMSR, CERES, and MODIS) will be completed in FY 1997, and the integration and test phase begun.

Chemistry Series

The Chemistry-1 mission, to be focused on the impact of greenhouse gases on global climate, is proceeding on schedule towards a 2002 launch. Chemism-1 instruments. including HIRDLS. MLS, TES, and the Japanese provided ODUS. are currently in Phase B definition. Significant accomplishments include the completion of the HIRDLS SCR and Phase C/D design and development proposal evaluation. MLS and TES have shown good progress and maturity in the overall design concept pertaining to their architecture, subsystem layout. and operational concepts. The HIRDLS phase C/D contract award (second quarter of FY 1996) and MLS, TES and ODUS SCR's will occur in FY 1996. The HIRDLS PDR and phase C/D efforts for MLS, TES and ODUS will occur in FY 1997.

Special Spacecraft

The FY 1995 National Defense Authorization Act asked that NASA and the Navy jointly study the possible convergence of their radar altimetry missions (EOS Altimetry Radar program based on TOPEX/Poseidon Follow-On (TPFO) and the Navy's Geosat Follow-On (GFO) program). The final study report recommends that EOS Altimetry Radar program based on TPFO be modified to meet the Navy's operational requirements. This approach would preserve NASA's science objectives, provide a timely follow-on to the TOPEX/Poseidon mission, continue established international collaboration with France, fit within the NASA budget, and satisfy Navy operational requirements with acceptable risk, at the least cost, to DoD.

PDR's for the French-provided satellite and altimeter for the EOS Altimetry Radar flight *are* scheduled for mid-FY 1996. The PDR for the U.S.-provided microwave radiometer (for altimeter corrections) will also occur in FY 1996. The engineering model of the altimeter will be delivered in the first quarter of FY 1997. The spacecraft and altimeter CDR's are scheduled for mid-FY 1997. The

engineering model of the microwave radiometer will be delivered in early FY 1997, and the CDR would be held in mid-FY 1997. Delivery of the "beta" version of the science software is also scheduled for mid-FY 1997.

The Altimeter Laser mission, focusing on ice topography and mass balance, continued Phase A technology definition for the Geoscience Laser Altimeter System (GLAS) instrument. Specific technical accomplishments were the demonstration of the laser diode lifetime, and hardware proof of concept development for the laser portion of the instrument. A result of a mission implementation study in August 1995 is a preliminary design concept for the spacecraft and instrument and the demonstration of mission feasibility. The GLAS instrument on the Altimeter Laser-1 mission will begin phase C/D in FY 1997.

The SAGE-111 instrument began Phase C/D development in November 1994. An implementing agreement was signed in December 1994, with the Russian Space Agency for flight of the first SAGE-111 in a polar orbit on a Russian Meteor-3M(1) spacecraft in August 1998. A second SAGE-111 instrument is planned to fly in an inclined orbit on the international Space Station in 2001. Design and development activities have progressed on schedule with the PDR completed in July 1995. The CDR for SAGE-111 is scheduled for late FY 1996. Fabrication and assembly of the first SAGE 111 instrument is planned for completion in late FY 1997.

The SeaWinds completed PDR in May 1995 and the CDR scheduled for January 1996. The SeaWinds instrument will be undergoing fabrication and assembly during FY 1996. SeaWinds instrument activities will consist of integration and test of the instrument, with the engineering model being delivered to the Japanese in mid FY 1997.

Phase B activities for the SOLSTICE instrument continue on schedule with the goal of supporting a flight opportunity in 2002. Efforts to identify a flight of opportunity included discussions with the Canadian Space Agency (CSA) investigating the possibility of accommodating SOLSTICE on one of the two NASA/CSA Scisat Program missions. SOLSTICE phase B activities will continue.

The ACFUM instrument phase B activities will continue. Options for a dedicated flight on a miniaturized spacecraft as well as a flight of opportunity with the Canada Space Agency are under study.

New Millennium Program

IPDT's were established to coordinate a cooperative effort to identify, develop, and deliver focused technologies to provide the needed capability. The first mission will be identified in the Spring of 1996.

Landsat

Development of the Landsat-7 flight and ground systems continued in FY 1995, with the spacecraft PDR in December 1994. All identified technical issues were resolved in the subsystem CDR's starting in mid-1995. The ground system, being built by GSFC, completed system requirements review in January 1995 and the PDR in July 1995. DoD obligations were completed with the transfer of $15M to NASA in September 1995. Development of the Landsat flight and ground systems will continue through

FY 1997, in support of the December 1998 launch. The Enhanced Thematic Mapper Plus (ETM+) instrument will be delivered in December 1996.

ASIS OF FY 1997 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Earth observing system data information system	220,600	241,200	261.100

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 increased understanding and observations of the environment.

STRATEGY F ACHIEVING GOALS

The EOSDIS will be based on 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. 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 became operational in 1994. Major development of the next two versions of the system are under way to prepare for the first flights of EOS instruments on TRMM in 1997 as well as the EOS AM-1 and Landsat 7 missions in 1998, to improve service to users, and incorporate new technologies.

The EOSDIS development has been divided into four major components: the EOS Data Operations System (EDOS) developed by TRW, the EOSDIS Backbone Network (EBNET) developed in-house by GSFC using Computer Sciences Corporation and Allied Signal, the EOSDIS Core System (ECS) developed by Hughes Information Technology 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 EBNET 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, which provides 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 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. In response concepts developed during the EOS reshape and the review by the National Academy of Sciences (NAS) Board on Sustainable Development, NASA is reviewing the DAAC functions.

The nine DAACs 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 (SEDAC). Saginaw, Michigan

The EOSDIS Version 0 allows direct access to some data holdings from the USGS and NOAA. 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 USGS. Department of Energy. NOAA, the Environmental Protection Agency. the United States Department of Agriculture, the DoD, the Department of the Interior. and the White House.

MEASURES OF PERFORMANCE

Release Version 0 Plan: August 1994 Accomplishment: August 1994	Provide processing support for the EOS pathfinder data sets. Support the design and development of EOSDIS Version 1
EOSDIS Version 1 Plan/Current: January 1997	Support the launch of the Tropical Rainfall Measuring Mission. (1996 budget (February 1996) plan corrected)
EOSDIS Version 2 Plan: November 1997 Current: October 1997	Support the launch of the AM-1 mission
EOSDIS Version 3 Plan: December 1999 Current: January 2000	Support the launch of the PM-1 mission

ACCOMPLISHMENTS AND PLANS

After release to the public in August of 1994, the Version 0 of EOSDIS user base. the number of users. has steadily increased. For example, in FY 1995 as new capabilities, more user awareness. and better accounting capabilities became available; the average usage metrics in running time shows: (1) the number of users doubling from November to September 1995, (from 5.000 users to 11,000), (2) total accesses increased from 37.000 to 100,000, (3) data requests increased from 3.500 to 5.700. and (4) volume distributed to requesters, in billions of bytes, increased from 377 to 1.667 per month.

Other major milestones completed in FY 1995 include: (1) the EOSDIS Version 1 PDR and CDR (2) the EOSDIS Version 2 PDR, and (3) the occupancy of the newly constructed EOSDIS building at the GSFC.

Major milestones for FY 1996 include the initial operational demonstration of the EDOS system, the delivery of Interim Release-1 of the EOSDIS system to support testing for TRMM and AM-1 software.

Major milestones for FY 1997 include the delivery of EOSDIS Version 1 system in January 1997. to support the TRMM mission and the work necessary to deliver Version 2 system in October 1997. FY 1998. to support AM-1 mission.

BASIS OF FY 1997 FUNDING REQUIREMENT

EARTH PROBES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
NASA scatterometer	15.400	7,700	--
Total ozone mapping spectrometer	14,900	8,500	2,600
Tropical rainfall measuring mission	51.300	24.200	20.900
Earth system science pathfinders	--	1,000	20.000
Experiments of opportunity	--	4,600	3,600
To	81,600	46,000	47,100

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 efforts or 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), and Earth System Science Pathfinders (ESSP).

STRATEGY FOR ACHIEVING GOALS

NSCAT

Because winds are a critical factor in determining regional weather patterns and global climate, 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 now planned for August 1996.

The launch of the Japanese ADEOS spacecraft was slipped from February 1996 when the Japanese experienced anomalies with the spacecraft during integration and test.

TOMS

The scientific objectives of the TOMS program 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 1996 (FM-3). The FM-4 is planned for launch on the Japanese ADEOS satellite in August 1996. The FM-5 was 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 TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. In addition, TRMM 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 effects of which 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.

The Japanese space agency (NASDA) is an active partner with all three Earth probes. providing the ADEOS spacecraft and H-11 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.

Earth System Science Pathfinder

The Earth System Science Pathfinder (ESSP) is a science-driven program intended to identify and develop *small* satellite missions to accomplish scientific objectives in response to national and international research priorities not addressed by current programs. ESSP will provide periodic "windows of opportunity" to accommodate new scientific priorities and infuse new scientific participation into the Mission to Planet Earth program. By launching ESSP missions on a frequent, regular basis. NASA will

provide a mechanism by which pressing questions in Earth system science may be addressed in a timely fashion, permitting a continual improvement in our understanding of the Earth system and the processes that affect it.

The ESSP first Announcement of Opportunity (AO) is being formulated with the following programmatic guidelines. The first two ESSP missions will be: focused on high-priority Earth system science research. limited to a total mission life cycle cost from NASA of $120 million, managed by the principal investigator as the single point of contact accountable for total mission implementation and success, developed in less than 36 months from development authority to proceed, and compatible with EOSDIS standards, including the immediate release of mission data to the scientific community.

Experiments Of Opportunity

Formally identified as Payload and instrument development, this program offers a unique capability to undertake short duration flights of instruments on the Space Shuttle and other platforms. The MTPE program has incorporated this capability into the Shuttle/Spacelab development in the important areas of design, early test and checkout of remote sensing instruments for free flying missions. and short term atmospheric and environmental data gathering for scientific analysis. Instrument development activities have supported a wide range of instrumentation. tailored for Space Shuttle and airborne missions.

MEASURES OF PERFORMANCE

Launch of TOMS flight model 3 Plan: July 1995 Current: March 1996	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 return to flight of the Pegasus XL/L1011.
Launch of TOMS flight model 4 & NSCAT Plan: February 1996 Current: August 1996	Launch is planned aboard the Japanese ADEOS spacecraft and H-II 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 calibration and validation completed successfully. Due to problems unrelated to TOMS and NSCAT. the ADEOS mission has been delayed.
Launch of TRMM Plan/Current: August 1997	Launch as planned aboard the Japanese H-II 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.
Launch of first ESSP mission Current: 1999/2000	First mission launch and other characteristics will based final mission selected thorough the AO.

ACCOMPLISHMENTS AND PLANS

Due to continued problems with the Pegasus-XL/L101 1 launch vehicle, the TOMS-EP has not been launched. The TOMS-EP is currently stored at TRW until the Pegasus-XL/L10 11 is certified for return-to-flight. The TOMS and NSCAT instruments have been installed on the Japanese ADEOS spacecraft. Due to problems unrelated to TOMS and NSCAT, the ADEOS mission has been delayed until August 1996. The TOMS flight model-5 instrument integration and assembly was completed.

The TRMM spacecraft bus integration began ahead of schedule, with assembly and installation of the spacecraft subsystems. The TRMM first instrument, the TRMM Microwave Imager. was delivered for integration into the observatory. The TRMM Science Data and Information System (TSDIS) preliminary design was completed.

NASA will release the AO for the inaugural ESSP missions in 1996. The final AO will be preceded by the release of a draft AO and the a pre-release conference to solicit comments to the AO. The first mission will launch in late 1999 or early 2000, followed by the second launch approximately 12 months later. Subsequent launches will occur at the rate of approximately one per year.

The ESSP program will emphasize flexible approaches for augmenting the global measurement objectives of the U.S. Global Change Research Program. The recent study by the National Academy of Sciences Board on Sustainable Development (1995) outlines strategic areas for which scientific research is needed in the context of critical Earth system science issues. While these areas do not exclusively define the scientific focus for early ESSP missions, the potential. key measurement needs for which new missions may be required in the next 5 years are outlined.

During the first half of FY 1996. the TOMS-EP is expected to launch. The TOMS Flight Model-4 and NSCAT instruments will undergo final integration and test aboard the Japanese ADEOS spacecraft with the launch of the ADEOS spacecraft planned for August 1996. In October 1995, the TRMM memorandum of understanding with Japan was signed. the second instrument, CERES, was delivered, and the TSDIS CDR completed. Plans for the remainder of FY 1996 include delivery of the remaining TRMM instruments: the Lightning Imaging Sensor (LIS) the VIRS, and the Japanese-supplied instrument, the Precipitation Radar (PR). The TRMM observatory will complete final integration and undergo several comprehensive performance tests. TSDIS will deliver its first build.

In FY 1997. the interface adapter module for the interface to the Russian Meteor will begin development for the TOMS Flight Model-5. The complete TRMM observatory will be shipped to Japan and launched from the Tanegashima Space Center. Selection of ESSP teams will be accomplished and design and development of the initial missions will begin in FY 1997.

The second flight of SIR-C as part of the Shuttle Radar Laboratory (SRL-2) mission in October. 1994, was the last MTPE full Space Shuttle payload. Several smaller payloads were flown on the Space Shuttle including the Atmospheric Laboratory for Applications and Science (ATLAS-3) mission flown in November. 1994, and the Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument in early FY 1996. Funding will allow for wrap-up activities for the SSBUV, ATLAS. and the Measurement of Air Pollution from Satellites (MAPS) instrument. Funding for post flight activities for SRL-1 and SRL-2 missions will continue.

In addition, the experiments of opportunity program supports flight instrument opportunities on foreign spacecraft, such as the cooperative commercial flight of MAPS on the Mir Space Station in FY 1997 and as the provision of Global Positioning Satellite (GPS) receivers for the Satellite de Applicaciones Cientificas-C (SAC-C) satellite with the Argentine Space Agency.

BASIS OF FY 1997 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Atmospheric payloads	7.600		
Solid Earth payloads	11,900		
To	19,500		

Beginning in FY 1996 the budget for payload and instrument development has been transferred to Earth probes and named experiment of opportunity. This change has been made because no full-spacelab missions are planned for MTPE.

BASIS OF FY 1997 FUNDING REQUIREMENT

APPLIED RESEARCH AND DATA ANALYSIS

	FY 1995	FY 1996	FY 1997	page Number
		(Thousands of Dollars)		
MTPE SCIENCE	254.500	248.200	277.100	SAT 3-32
Data purchase			50,000	
Research and analysis	164,600	145,000	145.000	
Mission science teams and guest observers	26,600	19,400	16,800	
EOS science	37.300	56,500	47,500	
Airborne science and applications	26,000	27,300	17.800	
OPERATIONS. DATA RETRIEVAL, AND STORAGE	107,300	89,600	102,000	SAT 3-36
Mission operations and data analysis	71,100	53,900	65.100	
High performance computing and communications - Earth and space sciences	20,500	26.100	28,300	
Information systems	9,700	9,600	8.600	
Socio-economic data application center	6,000	--	--	
To	361,800	337,800	379.100	

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 and flight instruments. the purchase and management of scientific data, and the provision of computing infrastructure. Each of the major components of applied research and data

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analysis has its own set of goals, strategies for achieving the goals, performance measures, and accomplishments. These will be discussed below.

BASIS OF FY 1997 FUNDING REQUIREMENT

MTPE SCIENCE

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Data purchase	--	--	50.000
Research and analysis	164.600	145,000	145.000
Mission science teams and guest observers	26,600	19,400	16,800
EOS science..	37,300	56,500	47,500
Airborne science and applications	26.000	27.300	17.800
To	254.500	248.200	277.100

PROGRAM GOALS

The goal for the MTPE science program is to contribute interdisciplinary scientific understanding of the 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

The research and analysis (R&A) science program is essential to the discovery of new concepts and to the design of future missions. The primary mode of research coordination occurs through the U.S. Global Change Research Program (USGCRP). 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. The type of basic research supported by R&A is exemplified by the work of Professors Rowland and Molina who received the 1995 Nobel Prize in chemistry for studies of stratospheric ozone. They made their original discoveries as a result of work supported by R&A funding.

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). EOS Interdisciplinary science 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. Modeling and data analysis research 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 predict global change through planning and support of laboratory and field studies, advanced instrument development, satellite and in sib. data analysis, and the development of process-scale models and numerical tools to aid in diagnosing and predicting natural and human-induced global environmental change. The outcomes of this research will be essential to U.S. leadership in designing sustainable development strategies for the 21st century.

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.

The airborne science program funds operations of two ER-2's, a DC-8. and a C-130. In FY 1997, the C130 aircraft will no longer be part of the airborne program. If a C-130 is needed to support Earth science investigations, another NASA C-130 may be used on an as needed basis. The program also funds operation and support of a core of remote sensing instruments and a facility for analyzing and calibrating data from those instruments. The specially modified aircraft serve as test beds for newly developed instrumentation and their algorithms prior to launch by ELVs or Shuttle. The instrumented aircraft provide remote sensing and in situ data for many earth science research and analysis field campaigns. including stratospheric ozone, tropospheric chemistry, and ecological studies throughout the world. The ER-2 aircraft, in particular, are unique in that they are the highest flying sub-sonic civilian research aircraft and were key in collecting in situ data for our understanding of ozone depletion and stratospheric transport mechanisms.

ACCOMPLISHMENTS AND PLANS

In FY 1997, NASA will initiate a data purchase program designed to acquire from commercial sources data sets not otherwise available that are necessary to accomplish the broad research goals of Earth system science. The current generation of data purchase to begin in FY 1997 derives from the experience of the Optical Transient Detector (OTD) and SeaStar/Ocean Color. The current generation data purchase contract will be executed in FY 1997 after a broad, agency competition. The budget authority will be liquidated only as acceptable data is delivered. Data product generation, data archival. science analysis, and all other NASA requirements are included in other elements of the MTPE budget.

In FY 1997, NASA will initiate a data purchase program designed to acquire data sets, rather than hardware to produce the data. from commercial sources. Such innovative methods of procurement were suggested in the Vice President's National Performance Review. The budget authority for the data sets purchased will be liquidated only as acceptable data is delivered, and the proposed contract will be executed with FY 1997 funds only after a broad, agency competition.

An international intercomparison and assessment of global vegetation models was conducted in Summer 1995. The summary report of results of the assessment was delivered in December 1995. Data from the Boreal Ecosystem-Atmosphere Study (BOREAS) will be analyzed and assessed to improve climate and weather models and to determine whether the study region is a

net source or sink of carbon and methane. The BOREAS results will also improve ecological models of the boreal forest biome needed for sustainable forestry. EOS investigators will utilize the data gathered in EOSDIS to perform integrated interdisciplinary studies of the Earth to enhance the capability to predict global climate change. The MTPE interdisciplinary science education strategy will continue to focus on sponsoring global change fellowships for highly qualified graduate students at U.S. universities. In FY 1996. approximately 160 graduate students will be funded under the EOS Interdisciplinary Science Fellowship Program.

The Airborne Visible Infrared Imaging Spectrometer (AVIRIS) will be used in FY 1995-FY 1997 for land imaging and applications research in preparation for the Small Spacecraft Technology Initiative Lewis mission: data collected by the Lewis spacecraft will be used to classify surface land cover and vegetation types. In FY 1996, we will complete the Multi-center Airborne Coherent Atmospheric Wind Sensor (MACAWS) development and science demonstration flights. The LIDAR 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 1997. A TOPEX/Poseidon mission review was held in November, 1995. The remarkable accomplishments of the TOPEX/Poseidon, specifically the capability for measuring ocean topography, are significantly improving the understanding of ocean circulation and ocean-climate interactions.

A workshop involving the participating investigators in the Interdisciplinary aerosol research program was 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 International Satellite Land Surface Climatology Project (ISLSCP), Pathfinder, Global Energy and Water Cycle Experiment (GEWEX), and scientific community in FY 1997. The global short-wave and long-wave SRB data sets (covering the period 1992 to 1995) will be extended to 1996. Validations of the satelllte-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 1997 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 1997. 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 and the results will be published in the scientific literature beginning in FY 1997. The Pacific Exploratory Mission central (PEM)-Central field campaign will be completed by October 1996. This field campaign will explore fundamental atmospheric chemical processes in the eastern tropical Pacific which is considered to be a 'clean" air region.

Savings will be achieved in FY 1997 due to policy changes suggested by the NASA Zero Base Review. One change in policy is that support contractors will no longer perform in-house science, research, and engineering.

MEASURES OF PERFORMANCE

The scientific issues of concern to MTPE are among the most complex and most policy relevant of any major scientific research program. The results of MTPE science are critical to the development of sound U.S. and global environmental policy, necessary for the long-term sustainable development. MTPE Science is focused on the following priorities: Atmospheric Ozone. Seasonal-to-Interannual Climate Prediction, Long-term Climate Variability, Land Cover Change, and Natural Hazards.

	FY 1995	FY 1996	FY 1997
Seasonal-To-Interannual Climate Variability	Improved Prediction with Coupled Ocean-Atmospheric Models	Evaluate Role of El Niño in Tropical Droughts	Provide Improved Sea Surface Winds to Prediction Models
Long-Term Climate System Variability	Role of Volcanic Aerosols in Climate	Role of Total Aerosol Burden in Climate	Tropospheric Ozone as a Climate Driver
Atmospheric Ozone Research	Complete Assessment of Stratospheric Chlorine Sources	Ozone Transport Field Campaign	Establish Role of Asian Emissions in Ozone Levels
Land Cover - Land Use	Satellite Methods for Deforestation in South America	Evaluate Hyperspectral Remote Sensing of Land Ecosystems	Tropical Rain forest - Climate: International Field Campaign
Natural Hazards	Dense Array GPS for Earthquake Studies	Strategic Plan for Remote Sensing of Flooding/Droughts	Initiate Program on Flood/Drought Assessment

BASIS OF FY 1997 FUNDING REQUIREMENT

OPERATIONS, DATA RETRIEVAL AND STORAGE

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Mission operations and data analysis	71,100	53,900	65.100
(Upper atmosphere research satellite operations and data analysis)	(24.300)	(14,600)	(15,300)
(Ocean topography experiment operations and data analysis)	(18,900)	(9,200)	(9,800)
(Total ozone mapping spectrometer operations and data analysis)	(3,700)	(3,300)	(2,500)
(NASA scatterometer operations and data analysis)	(--)	(2,400)	(13,000)
(Tropical rainfall measuring mission)	(--)	(--)	(4,900)
(Earth science mission operations and data analysis)	(24,200)	(24,400)	(19,600)
High performance computing and communications - Earth and space sciences	20,500	26,100	28,300
Information systems	9.700	9,600	8,600
Socio-economic data application center	6,000	--	--
To	107.300	89.600	102.000
Launch services (RadarSat)	(5,600)	(--)	(--)

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 ("OMS), and future missions such as the NASA Scatterometer (NSCAT) and the Tropical Rainfall Measuring Mission (TRMM), required to understand the total Earth system and the effects of humans on the global environment. 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 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) and information systems. The data and data products from the ODRS program have or will migrate to the EOSDIS.

Mission Operations and Data Analysis

The objectives of the Mission Operations and Data Analysis (MO & DA) program are to acquire, process. and archive long-tern 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 Earth Radiation Budget Satellite (ERBS) and processing of acquired data.

Key users of UARS data include NOAA, 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 NOAA, Russia (manifested a TOMS on their Meteor 3 satellite launched in 1991).Japan (has manifested a TOMS on their ADEOS satellite scheduled for launch in 1996) and Europe. Key ERBS users include a diverse set of institutions including NOM (manifested ERBE sensors on NOM-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. 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). The NSCAT participants include JPL. NOAA, 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. TRMM is a joint mission with the Japanese to measure tropical precipitation from a low inclination orbit. 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.

High Performance Computing and Communications - Earth and Space Sciences

The NASA HPCC program consists of four vertically integrated projects. These projects are: Computational Aeroscience (CAS), Earth and Space Sciences (ESS), Remote Exploration and Experimentation (REE) and Information Infrastructure Technology and Applications (IITA). The ITTA Project focuses on providing the technology base and applications to accelerate the implementation of the National Information Infrastructure.

The implementation of the NASA HPCC program is mainly through coordinated activities at NASA field Centers. The ESS project, lead by Goddard Space Flight Center (GSFC), will work in close partnership with industry. academia, and government. The Project used the NASA Research Announcement (NRA) process to select eight PI teams and twenty-one grand challenge investigations. IITA Remote Sensing Databases (RSD) project uses remote sensing data bases developed by NASA and other federally funded agencies to expand the application outreach of its programs to traditionally unserved communities. The Internet is used as the primary means of providing access to and distribution of science data and images and value-added products of the data and images.

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. 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. 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. 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.

Socio-economic Data Application Center (SEDAC)

The SEDAC objective is to increase understanding of the human dimensions of global change by developing and operating the data center in Saginaw, Michigan under contract to the Consortium for International Earth Science Information Network (CIESIN). The strategy is to focus specifically on development of SEDAC and its integration into NASA's Earth Observing System Data Information System (EOSDIS). SEDAC serves as a Distributed Active Archive Center (DAAC) and its funding has been

incorporated in the EOSDIS budget beginning in FY 1996. 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.

MEASURES OF PERFORMANCE

OPERATIONAL
SPACECRAFT/INSTRUMENTS

Common to all missions:

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 continuing operations	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 continuing Operations	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.
ERBS/ERBE/SAGE II (launched Oct. 1984, Dec. 1984 and Sept. 1986) continuing operations	Data from the ERBE and SAGE II must continue to be of sufficient accuracy to (1) illuminate the temporal and spatial variations in the Earth's radiation budget which drive the Earth's climate and (2) provide global data for aerosols, ozone, water vapor and nitrogen dioxide altitude profiles.
SBUV/2-SSBUV (launched Dec. 1984 and Sept. 1988) continuing	Data from the Solar Backscatter Ultraviolet/2 (SBUV/2) instruments provide column abundances and vertical profiles of atmospheric ozone. A carefully calibrated version of the same instrument, called Shuttle SBW (SSBUV) provides correlative measurements so that the TOMS and SBUV 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 (launched 1995) RadarSat (launched 1995) ADEOS (launched 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.
OTD launched 1995	The Optical Transient Detector (OTD) provides early acquisition of science data to support research in determining global distribution of lightning and its effects on climate change. It allows for an early engineering flight model 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.

SPACECRAFT TO BE LAUNCHED

SeaStar/Ocean Color 1996	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 Corporation. 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.
TOMS FM-3 to be launched March 1996 TOMS FM-4 to be launched August 1996	
NSCAT to be launched August 1996	NSCAT will measure surface wind speeds and directions over at least 90% of the oceans every two days in all weather and cloud conditions. It will fly on the Japanese ADEOS-1 spacecraft.

TRMM to be launched August 1997	TRMM is a joint United States-Japanese observatory program that will conduct systematic observations of tropical rainfall required for major strides in weather and climate research. TRMM is a U.S. spacecraft with both U.S. and Japanese instruments and will be launched on a Japanese H-11 rocket.
SEDAC CDR March 1995	The CDR is the Anal review of the system design before implementation. It is essential that NASA review the SEDAC system design to ensure interoperability with EOSDIS.

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 modellng 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 demand has led to a doubllng of production computing capacity and quadrupling of mass storage capacity in the last two fiscal years.

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. Additional missions supported will be those scheduled for launch in 1996 (TOMS. NSCAT, and SeaStar) , as well as the inauguration of data receipt from 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. 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. 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 and 1997 by continuing operations of on-orbit spacecraft and instruments including the UARS. TOPEX, and ERBS missions; 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 include the NSCAT and TOMS on ADEOS. TOMS Earth probe, and TRMM. 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.

BASIS OF FY 1997 FUNDING REQUIREMENT

GLOBAL OBSERVATIONS TO BENEFIT THE ENVIRONMENT (GLOBE)

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Global observations to benefit the environment.....	5.000	5.000	5.000

PROGRAM GOALS

The goal of the GLOBE program 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 levels of achievement in science and mathematics.

STRATEGY FOR ACHIEVING GOALS

The GLOBE program involves students (kindergarten through twelfth grades or equivalent) in schools throughout the world, their teachers and the research community. Participating schools are making core sets of GLOBE measurements using GLOBE instruments and procedures under the guidance of GLOBE-trained teachers. These results from all over the world are reported into a central data processing facility. The students then receive feedback and use GLOBE educational materials to understand the compiled results and 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 to contribute to the scientific understanding of the Earth is achievable due to the expansive data sets that result from long term, repeated measurements made in areas where data has in some cases been extrapolated 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 define the experimental procedures and data reporting protocols for each.

ACCOMPLISHMENTS AND PLANS

FY 1995 marked the development and initial implementation phase of the program. Over 2,000 U.S. schools have signed up to participate in the program, and more than 1,500 teachers have been trained from all 50 states. In addition, over 30 countries have signed bilateral agreements to participate in the GLOBE program.

In FY 1996, planning and implementation focuses on evaluating the initial program and transitioning to a long-term operational program. More emphasis will be placed on private partnerships, and the program will continue to scale up to broaden the participation in the program around the world.

During FY 1997. the program will continue to build upon and expand the initial core measurements, with input from scientists selected from a NSF-led peer review panel. Detailed plans developed in FY 1996 will be used to train the increasing number of teachers. thus facilitating a rapid growth in the number of schools participating in the program.

MEASURES OF PERFORMANCE

Achieve participation of at least
200 schools
Plan: April 1995
Accomplished: April 1995

Double the number of
participating schools
man: September 1996

BASIS OF FY 1997 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Advanced communications technology satellite	2.300	--	--

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 Lockheed Martin 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 deployed by the shuttle on September 12. 1993, and arrived on station in geostationary orbit approximately two weeks later. After the satellite, the master control station and multiple Earth stations were checked out, 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 was transferred to the Office of Space Access and Technology.

BASIS OF FY 1997 FUNDING REQUIREMENT

LAUNCH SERVICES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Launch services.....	62.200	107.100	124.100

PROGRAM GOALS

The goal of the launch services within the Mission to Planet Earth program is to provide the flight programs with cost-effective. on-time expendable launch vehicle (ELV) launch sexvices.

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' dellvery 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 dellvery to space.

Since 1987, the LVO has been employing a national mixed fleet strategy. with 100% 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 11, Pegasus XL, and Delta 11, 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 Lockheed Martin for AM-1, McDonnell Douglas for Landsat-7 and RadarSat, and Orbital Sciences Corporation for TOMS.

MEASURES OF PERFORMANCE

Launch of RadarSat Plan: Accomplished:	 4th quarter 1995 November 1995	Launched 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.
Launch of TOMS-EP Plan: Current:	 July 1995 March 1996	Launch aboard the Pegasus XL/L1011 launch vehicle. Exact date of this launch is dependent upon the return to flight of the Pegasus XL/L1011.
EOS AM-1 Current:	 June 1998	
Landsat-7 current:	 December 1998	

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 Pegasus return to flight. Lockheed Martin Commercial Launch Services was selected as the Intermediate ELV (IELV) launch services contractor.

The key goal is to provide launch of the TOMS 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 1997 FUNDING REQUIREMENT

CONSTRUCTION OF FACILITIES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Earth system science building	17,000	17,000	--
Construction of facilities	17,000	17,000	--

PROGRAM GOALS

The goal of the Earth system science building (ESSB) project is to construct facilities that will house civil service, contractor, and visiting scientists conducting global change and Earth science research using the Earth Observation System (EOS).

STRATEGY FOR ACHIEVING GOALS

Facility design and initial construction began in FY 1994 for the 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 1997 budget justification.

Aeronautical
Research and
Technology

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS — AERONAUTICAL RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	Page Number
		(Thousands of Dollars)		
Aeronautical research and technology	823,500	845,900	857,800	SAT 4-4
Construction of facilities	22,000	--	--	SAT 4-45
To	845,500	845,900	857,800	
National aeronautical facilities	35,000	--	--	
Distribution of Program Amount By Installation				
Kennedy Space Center	100	--	--	
Marshall Space night Center	2.000	2,100	2,100	
Stennis Space Center	300	--	--	
Ames Research Center - SAT	221.400	203,600	204,600	
Ames Research Center - Cofl?	22,000	--	--	
Dryden Flight Research Center	46.300	55,100	67,600	
Langley Research Center	289,200	306,900	307,000	
Lewis Research Center	244,200	258.900	263,800	
Goddard Space Flight Center	4.400	4.300	4,700	
Jet Propulsion Laboratory	2,400	2,000	1,700	
Headquarters	13,200	13,000	6,300	
To	845,500	845,900	857,800	

OFFICE OF AERONAUTICS **AERONAUTICAL RESEARCH AND TECHNOLOGY**

PROGRAM GOAL

The goal of the Aeronautics Research and Technology program is to provide the Nation with leadership in high-payoff, critical aeronautical technologies, and to ensure 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, environmentally responsible, and economically superior U.S. civil and military aircraft, and for a safe, productive national airspace system.

STRATEGY FOR ACHIEVING 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 aeronautical safety, environmental, airspace productivity, and aircraft performance needs and to strengthen technology development in selected high-payoff areas vital to the Nation's long-term leadership in aviation. NASA's aeronautics program is focused around six strategic thrusts:

- Develop high-payoff technologies for a new generation of environmentally compatible, economic U.S. subsonic aircraft and a safe, highly productive global air transportation system:
- Ready the technology base for an economically viable and environmentally friendly high-speed civil transport:
- Ready the technology options for new capabilities in High Performance aircraft;
- Develop and demonstrate technologies for airbreathing hypersonic flight:
- Develop advanced concepts, physical understanding. and theoretical, experimental. and computational tools to enable advanced aerospace systems: and
- Develop, maintain, and operate critical national facilities for aeronautical research and for support of industry, the FAA, DOD, and other NASA programs.

To achieve these goals. the Aeronautics Enterprise will increase customer review of program planning and execution: emphasize the use of low-cost experimental aircraft to increase flight opportunities: and reduce and rationalize infrastructure via centralized facility management. the designation of Centers of Excellence. and national alliance activities. The Center of Excellence concept

will serve to focus the in-house research program, provide single points-of-contact for management and external customers. and ensure maximum cost effectiveness.

PERFORMANCE MEASURES

All programs within the Aeronautics Enterprise use clearly defined and measurable Level I milestones to track program performance against the program plan. Level I milestones are defined as customer negotiated and approved product and service deliverables that are identifled in formal Level 1 Program Plans. Progress against these milestones serves as a critical metric for program performance evaluation.

In addition, specific quantitattve or qualitative success/exit criteria have been defined as critical program performance metrics for each milestone to enable a determination of successful milestone achievement. These measures of overall program performance measure both effectiveness and efficiency relative to program plan technical, schedule and resource requirements.

BASIS OF FY 1997 FUNDING REQUIREMENT

AERONAUTICAL RESEARCH AND TEC BASE

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Aerodynamics..	119,200	113,900	109,600
Propulsion and power	64.600	62,700	62.400
Materials and structures	37,800	36,500	35.500
Controls. guidance, and human factors	46,300	48.300	48,200
Flight systems	55,000	54,900	51,100
Systems analysis	11,400	14,000	7,600
Hypersonics/advanced research	20.000	20.000	40.000
To	354.300	350.300	354.400

PROGRAM GOALS

NASA's Aeronautics Research and Technology (R&T) Base program provides a foundation to develop advanced technology concepts and methodologies for application to industry: to build focused programs to address selected national needs: to respond quickly to critical safety, security, and environmental issues: and to provide facilities and expert consultation for industry during their product design and development process.

STRATEGY FOR ACHIEVING *GOALS*

NASA, working closely with its customers. leads the world in aeronautical research breakthroughs and advanced aviation concepts. The R&T Base program has responded to critical national needs for technology development in areas such as fuel-efficient propulsion concepts. composite secondary structures, winglets, supercritical wings, and improved high-lift systems. The R&T Base program accelerates technology development, validation, and transfer and also provides the capability for NASA to quickly and effectivelyrespond to critical problems identified by other agencies, industry, or the public. Examples of these problems are: aging aircraft; aircraft accident investigations; lightning effects on avionics: flying safety; wind shear; shuffle tiles and landing gear; crew rest: fatigue: andjet lag. and aircraft stall spin. The R&T Base program supports and maintains the capability to implement and conduct disciplinary research. as well as provide the infrastructure to support future focused programs. The major facilities and services are located at the four aeronautical Centers of Excellence--Ames Research Center, Dryden Flight Research Center, *Langley* Research Center, and Lewis Research Center.

Today, the U.S. leadership position in aeronautics is being seriously challenged by aggressive international competition. Future U.S. competitiveness is dependent upon sustained NASA advances in aeronautics. Critical elements of NASA's contribution to the aviation industry are the flow of new ideas and concepts. the ability to react quickly to unanticipated technical challenges, and the

fundamental knowledge produced by the R&T Base. Factors underlying the dominant role of NASA in aeronautical research include: the extensive research facilities required (NASA facilities' current replacement value is estimated at over $6 billion): the large disincentives for private sector investment in long-term, high-risk aeronautical R&T stemming from the inability of individual companies to fully capture the benefits from these research efforts: the length of the aircraft research and development cycle and the investment recoupment period: the extensive breadth and depth of technologies required to produce a superior aircraft; the public-good character of much of the research (safety, environment, certification, national security): and the base of experienced NASA technical personnel.

The majority of the R&T Base research includes the following principal aeronautics disciplines: aerodynamics: propulsion and power; materials and structures: controls. guidance, and human factors: flight systems: systems analysis: and hypersonics. The R&T Base program also provides the resources required to maintain aeronautics flight research, as well as ground-based experimental and computational facilities. Emphasis in systems analysis and multidisciplinary research (the combining of two or more disciplines in a single activity) has increased because of the potential improvements in aircraft systems with integrated design approaches. Each element of the R&T Base program has an objective to develop methods that will contribute to the U.S. aerospace industry goal of reducing design cycle time by at least 50%. The need to reduce product costs and capture increased market share drives this goal. The R&T Base also maintains research in all vehicle classes and provides the only funds for the essential research necessary for future advances in High Performance aircraft. A significant portion of the research and concept development in the R&T Base includes cooperative agreements with the aerospace industry and other government agencies to facilitate rapid technology transfer.

MEASURES OF PERFORMANCE

FY 1995 Milestones		Performance Metric
Aerodynamics		
Validate the computational methods in transonic flow		Evaluate a new computer code to compare calculated Reynolds number effects for a wing and a wing/body configuration with experimental data.
Plan:	**9/95**	
Accomplished	**9/95**	Algebraic Reynolds Stress Model implemented into the Reynolds-Averaged Navier-Stokes (RANS) code (Computational Fluids Lab 3-dimensional) revised method gives substantially better agreement in attaching flows.

Propulsion and Power	
Transfer of dynamic analysis code for helical gear Plan: **6/95**	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.
Accomplished: **6/95**	Code has been developed, and **will** be distributed after final validation.
Transfer low nitrogen oxide simulation codes to industry. **Plan:** **9/95**	Hold industry workshop to instruct users and transfer codes.
Accomplished **9/95**	ALL SPEED-3D code validated via test cases. Industry workshop planned.
Materials and Structureg	
Demonstrate weight reduction fuselage panels. Plan: **9/95**	Validate structurally efficient wing and fuselage concepts which would allow for a **15%** wing and fuselage weight reduction.
Accomplished: **9/95**	Structural efficiency studies of several composite panel concepts loaded in compression demonstrate weight reductions of **25%** to **35%** compared to stiffened-skin aluminum panel concepts.
Controls. Guidance. and Human Factors	
Demonstrate real-time system for measuring level of pilot awareness. Plan: **12/94**	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.
Accomplished: **12/94**	Prototype real-time system employed in experiments in Advanced Civil Transport Simulator *(ACTS)* and Transport Systems Research Vehicle (TSRV) simulators.
Demonstrate computer-aided low altitude guidance. **Plan:** **9/95**	Identify and implement methods for increasing pilot awareness and reducing human error using active sensor augmentation.
Accomplished: **9/95**	Algorithms developed and integrated aboard the **Army UH-60** Systems Testbed for Avionics Research *(STAR)* helicopter for flight test. Low-altitude missions successfully night demonstrated in moderately rugged terrain **with** unmapped obstacles.

Flight Systems	
Validate 2-dimensional ice accretion prediction code. Plan: 9/95	Evaluate advanced ice accretion computer code and transfer to industry through instructional workshops.
Accomplished: 9/95	Lewis Ice Accretion (LEWICE) code version 1.6 transferred to industry via workshop.
Complete flight evaluation of advanced aerodynamic control. Plan: 9/95	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.
Accomplished: 12/95	Flight test data measured and available for comparison with computational, wind tunnel and simulator predictions. Additional ground tests were required to achieve a high quality flight evaluation, resulting in delay in achieving milestone.
Initiate assessment of axisymmetric vectoring exhaust nozzles on the F-15 research aircraft. Plan: 9/95	Complete F-15 aircraft modifications and clear the aircraft for flight by the Air Worthiness and Flight Safety Review Board.
Accomplished 12/95	Installed engines with axisymmetric exhaust nozzles and associated systems and completed final ground tests on ACTIVE aircraft. Aircraft cleared for flight in 12/95. Delay in achieving milestone due to late engine delivery.
Systems Analysis	
Complete selection of flexible synthesis architecture approach. Plan: 9/95	Select best approach and initiate conversion of design codes.
Accomplished 9/95	Selected object-oriented architecture. Conversion of AirCraft Systems INTegration (ACSYNT) and VSTOL Aircraft Sizing Computer Program (VASCOMP) began in July 1995.

Hypersonics

Pegasus wing-glove completion. Plan: 7/95	Complete wing-glove and data system - to be mounted on the next available Pegasus for FY 1996/7 flight.
Accomplished: 12/95	Progress paced to be consistent with revised launch window.
University grant reviews. Plan: 9/95	Review FY 1995 results and prepare for the final year at the set of three universities.
Accomplished: 1/96	Initial FY 1995 review held in June 1995. Final FY 1995 review in January 1996.

FY 1996 Milestones

Aerodynamics

Assess tiltrotor noise alleviation. Plan: 6/96 Current: 6/96	Complete a computational method for noise control and evaluate the method with experimental data.

Propulsion and Power

Deliver a preliminary conceptual analysis of the Numerical Propulsion System Simulator (NPSS). Plan: 3/96 Current: 3/96	Deliver the NPSS to the propulsion and aircraft industry and ensure all critical capabilities fully functional as judged by the NASA/Industry cooperative technical focus group.

Materials and Structureg

Demonstrate strength and toughness of emerging aluminum alloys. Plan: 3/96 Current: 3/96	Confirm that data from validation coupon testing predicts new aluminum alloys produced by novel intermediate rate solidification process.
Demonstrate accuracy of flutter prediction. Plan: 9/96 Current: 9/96	Demonstrate though benchmark tests that calculations of transonic wing flutter are accurate to within 5% through the inclusion of viscous effects.

Evaluate the noise reduction identifled which enable 6dB reduction. Plan: 9/96 Current: 9/96	Demonstrate through experimental testing that sufficient concepts show potential of innovative rotor noise reduction relative to conventional concepts rotor systems without sacrificing aerodynamic performance.
Controls. Guidance. and Human Factors Demonstrate use of computer-controlled engine thrust. Plan: 9/96 Current: 9/96	Using an MD-11 aircraft, demonstrate the ability to safely land in a simulated emergency. using engine thrust computer control *only.*
Complete field evaluation for extended terminal air traffic controller aids. Plan: 9/96 Current: 9/96	Evaluate concepts. technologies and procedures which will support the FAA development plans.
Complete initial civil tiltrotor terminal area simulation using Man/Machine Integrated Design and Analysis System (MIDAS) *to* analyze proposed cockpit designs and crew procedures. Plan: 9/96 Current: 9/96	Obtain human performance and workload data resulting from a notional civil tiltrotor cockpit design applied to a selection of feasible terminal area scenarios.
Flight Systems Demonstrate operability and real-time performance optimization of thrust vectoring exhaust nozzles. Plan: 9/96 Current: 9/96	Using the F-15 research aircraft, quantify performance of 'care-free" engine/nozzle operation throughout the flight envelope and demonstrate performance improvements.
Complete initial flight evaluation of neural network flight controls on F-15 ACTIVE Research Aircraft to enable reduced development and operational costs. Plan: 9/96 Current: 9/96	Demonstrate capability to identify key aircraft parameters in flight using neural net flight controller.

Initial flight evaluation of neural network flight controls. Plan: 9/96	Flight control performance on the F-15 research aircraft will equal or exceed conventional flight control system performance.
Current: 9/96	The existing metric represents the ultimate objective of this research program. The appropriate metric for this initial flight evaluation is: Demonstration of the capability to identify key aircraft parameters in real-time, in-flight. using a neural net flight controller.
Complete flight assessment of aerodynamic control concepts. Plan: 9/96 Current: 9/96	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.
<u>Hypersonics R&T</u> Mach 6.5 scramjet ground test. (Russian Central Institute of Aviation Motors (CIAM) contract) Plan: 2/96 Current: 2/96	Demonstrate system performance and operability in simulated environment.
<u>FY 97 Milestones</u>	
<u>Aerodynamics</u> Implement Rotorcraft Centers of Excellence (RCOE) program. Plan: 12/96	Announce selections and implement cooperative agreements with up to three universities as Rotorcraft Centers of Excellence.
Develop turbulence model for two-dimensional high-flows at realistic Reynolds numbers. Plan: 3/97	Create turbulence model that predicts wake spreading and slat effects implemented into a 2-dimensional Reynolds-Averaged Navier-Stokes (RANS) code and compare results with 737 flight-test data.

Propulsion and Power Demonstrate advanced. small gas turbine combustor operatlng at 3,000 degrees Fahrenheit (+600 degrees Fahrenheit improvement) with a minimally cooled liner. Plan: 3/97	Establish design criteria and concept for small engine combustor. Validate combustor in component rig testing. Transfer results to U.S. Industry.
Materials and Structureg Develop advanced thermal barrier coatings for ceramic composites and transfer to industry. Plan: 2/97	Demonstrate effective coating in lab scale test environment (coated ceramic room temperature strength retained after 100 hours at 1,052 degrees centigrade hot corrosion).
Provide materials systems and processing to enable compressor discharge temperatures of 1,500 degrees Fahrenheit (currently 1,200 degrees Fahrenheit). Plan: 4/97	Demonstrate compressor disc in spin pit test at 1,500 degrees Fahrenheit. Transfer compressor material technology to U.S. engine companies.
Controls, Guidance, and Human Factors Demonstrate multidisciplinary modeling, synthesis. and analysis methods to enable efficient and accurate design of control systems for aircraft with complex structural, aerodynamic, and propulsion interactions. Plan: 3/97	Complete and distribute beta version of software code to industry for application.
Flight Systems Complete flight validation of multi-axis control power requirements design criteria Plan: 10/96	Validate multi-axis control power predictions and transfer design criteria and guidelines to industry.

Systems Analysis Incorporate economic and risk subroutines into systems analysis methodology. Plan: 1/97	Demonstrate that method is operational and predicts effects of economics and risk on critical design parameters.
Hypersonics/Advanced Research Mach 6.5 scramjet flight test. (Russian CIAM contract) Plan: 11/96 Current: 11/96	Demonstrate system performance and operability in flight.

ACCOMPLISHMENTS AND PLANS

Significant accomplishments for FY 1995 in the area of aerodynamics include the establishment of a baseline subsonic transport configuration with industry and the identification of advanced Laminar Flow Control (LFC) and high-lift concepts and methods. Also, NASA installed an algebraic Reynolds Stress turbulence model into the Reynolds-Averaged Navier-Stokes (RANS) code. Computational Fluids Lab 3-Dimensional. This revised method gave substantially better agreement for reattaching flows and has helped validate Reynolds number effects in transonic wing and wing/body flows for subsonic and supersonic transports. In FY 1996. NASA will develop a framework for transition prediction to provide an industry standard tool. NASA will work with industry to complete this project and gain acceptance for industrial use of the tool. The program will complete the development of computational methods that analyze tiltrotor noise and will evaluate the accuracy of these methods with experimental data. These methods will enable the analysis of noise control concepts. Research will include a wind tunnel evaluation of a fan-in-fin concept for increased safety and performance for rotorcraft operation and the use of these results for validation. In 1996, the Rotorcraft Industry Technology Association (RITA) will complete some of the manufacturing affordability research projects and initiate new work on rotorcraft related aviation infrastructure issues and harmonization of curve/military standards. In FY 1997, the aerodynamics program anticipates developing a turbulence model for two-dimensional high-lift applications. The model should predict wake spreading and slat effects implemented in 2-dimensional RANS codes. Flight tests on the 737 will provide comparison data for determining the accuracy of the turbulence model.

During FY 1995, propulsion and power accomplishments included the development of simulation methods for the analysis and design of low emission combustors for gas turbine engines. The program also validated (through comparison with experimental data) and released the first dynamic analysis code allowing non-empirical prediction of gear life and noise level for helical gears. Industry received this technology during a workshop conducted in May 1995. During FY 1996, the propulsion program will deliver a preliminary analysis and design version of the Numerical Propulsion System Simulator (NPSS) to the propulsion and aircraft industry. This version of the NPSS will include all critical capabilities required by a NASA/Industry cooperative technical focus group. This cooperative group will also judge those capabilities as fully functional before release of the technology. NASA will release a dynamic analysis code allowing non-empirical prediction of gear life and noise levels for helical gears for rotorcraft applications. Plans for FY 1997 include the demonstration of advanced, small gas turbine combustors operating at 3,000 degrees

Fahrenheit (+600 degree improvement) with a minimally cooled liner and the validation of combustor computational methods that will enable combustor designs with reduced emissions

Accomplishments during FY 1995 in materials and structures include the development of structurally efficient concepts for wing and fuselage skin panels. Studies of several composite panel concepts loaded in compression demonstrated weight reductions of 25% to 35% compared to stiffened-skin aluminum panel concepts. Under a cooperative arrangement, engine companies received fabricated coupons of advanced ceramic and intermetallic materials for evaluation in test engines. NASA developed and patented those coupons. Research efforts successfully demonstrated a concept for reducing rotorcraft vibration during a joint industry wind tunnel test. This program will extend into FY 1996 to verify the flutter stability of an 18% thick wing with active controls on the wing control surfaces and rotor swash plate. In FY 1996, the program plans to demonstrate strength and toughness combinations of emerging aluminum alloys produced by novel solidification processes: and improve the accuracy of computational predictions of transonic wing flutter to within 5% by incorporating viscous effects. U.S. engine companies. NASA, and the Air Force will cooperatively develop the framework of a life prediction code for metal-matrix composite engine components. For FY 1997, materials and structures research plans include the provision of materials systems and processing to enable compressor discharge temperatures of 1500' Fahrenheit (currently 1.200' Fahrenheit): and the development of advanced thexmal barrier coatings for ceramic composites. NASA will transfer the coatings to industry.

Significant accomplishments in the controls, guidance, and human factors program for FY 1995 include the demonstration of computer-aided low altitude guidance using active sensors for rotorcraft. A flight test using the Army UH-60 Systems Testbed for Avionics Research (STAR) helicopter provided successful missions in moderately rugged terrain with unmapped obstacles. The program also demonstrated real-time system measuring levels of pilot awareness based on psychophysiological data. The Advanced Civil Transport Simulator (ACTS) and Transport Systems Research Vehicle (TSRV) simulators provided a prototype real-time system for these experiments. NASA conducted a flight demonstration of a laser radar forward sensor incorporated into the NASA/Army Terrain Following Terrain Avoidance guidance system. The test program used moderately rugged terrain in the presence of unmapped obstacles. In FY 1996, the program will flight demonstrate the use of computer-controlled engine thrust for emergency flight control. Research projects will evaluate concepts. technology, and procedures for extended terminal area air traffic controller automation aids. The program will complete initial tiltrotor terminal area simulations using Man/Machine Integrated Design and Analysis System (MIDAS) to analyze proposed cockpit designs and crew procedures. In FY 1997. controls, guidance, and human factors will provide multidisciplinary technology developments to enable methods for efficient and accurate design of control systems for aircraft with complex aerodynamic, structural. and propulsion interactions.

In the area of flight systems, FY 1995 accomplishments include the validation and transfer to industry of a computer code that more accurately designs and analyzes thermal ice protection systems. Additionally, the flight systems program completed installation of axisymmetric vectoring exhaust nozzles on the F-15 Advanced Controls Technology Integration for Vehicles (ACTIVE) research aircraft to demonstrate increases in range and maneuvering capability and established a flight test envelope for an advanced flight test fixture on the F-15B testbed aircraft. In FY 1996, flight research will include an investigation of community noise impacts from helicopters and demonstrate flight procedures offering significant reductions in noise. The program will also complete flight evaluation of advanced aerodynamic controls for increased maneuverability on the High Angle-of-Attack Research Vehicle. Flight research with the F-15 ACTIVE Aircraft will demonstrate substantial performance benefits from the real-time

performance optimization of integrated flight and propulsion controls. Flight research will include the initial flight evaluation of a neural network-based flight control system that offers the potential for reduced development and operational costs on the ACTIVE aircraft. In FY 1997, plans include completion of flight validation of design criteria for multi-axis power controls.

In FY 1995, systems analysis methods development progressed toward a flexible synthesis architecture with the selection of an object-oriented approach for the AirCraft Systems iNTegration (ACSYNT) and VSTOL Aircraft Sizing Computer Program (VASCOMP) design codes. Conversion of these codes will continue into FY 1996. Other methods-development work in FY 1996 will include development of an economic analysis of production costs for incorporation into a flight vehicle analysis code. Application of systems analysis in FY 1996 will include agile supercruise aircraft and general aviation aircraft conceptual designs to identify technology needs. In FY 1997, the program will incorporate economic and risk subroutines into systems analysis methodology to demonstrate that method is operational and predicts the effects of economics and risk on critical design parameters.

During FY 1995. NASA hypersonics focused largely on aeropropulsion and aerodynamics. FY 1995 work on the Pegasus wing-glove-experiment hardware will enable the flight-test in FY 1997 on hypersonic boundary-layer transition. The university hypersonic curricula programs satisfied their mandate of performing first class hypersonic research in conjunction with NASA's aeronautic research centers and will build on this success in FY 1997. Progress on the Russian Central Institute of Avlation Motors (CIAM) contract in FY 1995 is leading to both wind-tunnel and flight-test data in FY 1996 on fundamentals of ramjet/scramjet transition. Ground tests at Mach 4 to 17 are consolidating and enhancing the data base for scramjet performance and operability (FY 1995 and 1996). The key ground tests with the large-scale Concept Demonstrator Engine model will be tested at Mach 5 to 7 test conditions in FY 1996. In the second quarter of FY 1996, the program will determine the specific flight-test projects for implementation through X-planes. The leading candidates include projects for generat-aviation engines and airframe-integrated scramjets. Hypersonics is expanded to include advanced research. In FY 1997, NASA and CIAM will jointly complete a Mach 6.5 scramjet flight test to demonstrate system performance and operability in flight.

BASIS OF FY 1997 FUNDING REQUIREMENT

FOCUSED PROGRAMS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
High performance computing and communications	51,600	32,200	23,300
Advanced composite technology	24,300	--	--
Numerical aerodynamic simulation	46,200	48,100	38,600
High-speed research	221,300	245,500	254,300
Advanced subsonic technology	125,800	169,800	187,200
To	469,200	495,600	503,400

NASA's Aeronautics focused programs address selected national needs, clearly defined customer requirements and deliverables, critical program decision and completion dates. and a specified class of research with potential application. Each of the focused programs are discussed in detail on the following pages.

BASIS OF FY 1997 FUNDING REQUIREMENT

	FY 1995	FY 1996 (Thousands of dollars)	FY 1997
High performance computing and communications...	51.600	32,200	23,300

PROGRAM GOALS

Studies have shown that High Performance computing technologies have a significant 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: Computational Aerosciences (CAS), Earth and Space Sciences (ESS), Remote Exploration and Experimentation (REE) and Information Infrastructure Technology and Applications (IITA). 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 has the goal of developing and demonstrating a space-qualified, spacebom computing architecture that requires less than ten watts per billion operations per second. The IITA project 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 by providing rapid and painless access to NASA assets, such as Earth and space remote sensing data. 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 "stakeholder" 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 year to ensure the program is achieving its stated goals, and is staying within schedule and budget.

NASA has conferred with senior executives from major U.S. aerospace companies to plan the Computational Aerosciences (CAS) project *to* best respond to long-term customer requirements. In the summer of FY 1994, revisions to the CAS program plan were initiated based on industry input to better transfer CAS technology projects to industry. A new thrust was developed to facilitate the utilization of the existing computational infrastructure of the aerospace, embodied in a NASA Cooperative Agreement Notice (CAN) that was issued and awarded in FY 1995. Managers of the HPCC program periodically visit and interact with industry leaders to better understand industry's critical long-term 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. This initiative is planned to continue through FY 1998. NASA, in conjunction with NSF and ARPA, now co-fund six digital library projects. 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 established a cooperative agreement with a consortium led by IBM to develop a high performance computing capability In computational aerosciences. Additional agreements will be awarded, as required, to meet future research needs.

Beginning in FY 1997, components within the HPCC program will be reallocated to the benefiting program offices. The ESS project and the remote sensing component of ITA will be reallocated to Mission to Planet Earth, REE will be reallocated to Space Science, and the educational activities within ITA will be allocated to programs within Education programs and Minority University Research and Education programs. Aeronautics will retain the CAS program along with the digital libraries component of ITA. FY 1995 and FY 1996 has been restructured for display purposes to show this transfer.

	FY 1995	FY 1996	FY 1997
	(Thousands of Dollars)		
Aeronutical R&T	(51.6)	(32.2)	23.3
Mission to Planet Earth	(20.5)	(26.1)	28.3
Space Science	--	(0.6)	3.2
Education Programs	(2.4)	(2.5)	2.7
Minority University & Education	(1.6)	(2.2)	1.4
Total HPCC	**76.1**	**63.6**	**58.9**

MEASURES OF PERFORMANCE

FY 1995 Milestones	Performance Metricg
Demonstrate satellite-based gigabit applications using Advanced Communications Technology Satellite (ACTS) and associated ground terminals Plan: 6/95	Demonstration of 155 & 622 Mbps satellite/terrestrial connectivity among geographically distributed computational platforms .
Accomplished: 9/95	Demonstrated satellite-based Gigabit per second communication by linking ACTS with terrestrial computer networks. Actual completion was delayed to 9/95 due to hardware failures in the ground stations.

FY 1996 Milestones	
Demonstrate multidisciplinary CAS & ESS applications on 10-50 gigaFLOPS testbeds Plan: 9/96 Current: 9/96	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. man: 9/96	Milestone was re-written because it was not measurable as worded.
Demonstrate cost effective high performance computing at performance and reliability levels equivalent to 1994 vector supercomputers at 25% of the capital cost. Current: 9/96	Demonstrate practical workstation cluster solutions at performance and reliability levels equivalent to FY 1994 vector supercomputers at 25% of the cost.

FY 1997 Milestones

Demonstrate high-speed interconnects over NREN. **Plan:** 9/97	Demonstration of 622 Mbps interconnection for multi-site projects.
Demonstrate integrated, multidisciplinary aerosciences applications on teraFLOPS-scalable testbeds. Plan: **9/97**	Demonstrate execution of CAS Grand Challenge applications on teraFLOPS-scalable testbeds.

ACCOMPLISHMENTS AND PLANS

In FY 1995, the *CAS* project developed High-speed Civil Transport (HSCT) analysis and optimization codes to perform medium fidelity HSCT modeling, and demonstrated 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 was issued. In support of the National Research and Education Network NASA interconnected five of its research centers through a high-speed, 155 megabits per second network. NASA also demonstrated satellite-based gigabit per second communication by linking the Advanced Communications Technology Satellite with terrestrial computer networks.

In FY 1996, the NASA HPCC planned program accomplishments 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: and (5) demonstrating cost effective High Performance computing at performance and reliability levels equivalent to FY 1994 "Vector" supercomputers at 25% of the capital cost.

The HPCC program has been a highly successful program. It has focused primarily on *high* performance-scalable systems. The Office of Aeronautics will retain the CAS program and the digital libraries component of IITA. In FY 1997, the HPCC program plans to complete the TeraFLOPS scalable CAS parallel benchmarks started in FY 1996, demonstrating high-speed (622 Mbps) interconnects over the National Research and Education Network (NREN) for multi-site projects, and demonstrate results of mature digital library technology projects.

	FY 1995	FY 1996	FY 1997
		[Thousands of Dollars)	
Advanced composites technology..	24,300	--	--

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. 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 were 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 was developed and tested. The wing concept exploits through-the-thickness stitching of dry fiber material and resin transfer molding, and the fuselage were fabricated by a combination of automated fiber placement and textile preforms. NASA's Langley Research Center (LaRC) developed 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 strength-tested in the LaRC 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.

MEASURES OF PERFORMANCE

FY 1995 Milestones	Performance Metrics
Fabricate and test window-belt panels Plan: 6/95	Establish cost effective design 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 reparability at least equal to that of baseline aluminum structure.
Accomplished: 6/95	Panels met ACT cost and weight goals. Four panels ranging in size from 3' by 5' to 7' by 10' were fabricated with processes that can easily be fully automated. The basic design was honeycomb core sandwich, braided resin transfer molded window belts and advanced fiber-placed face sheets. All NDE results indicated excellent panels. Panels were loaded under combined internal pressure and biaxial tension in the Langley Pressure Box. The design ultimate load of 2400 lbs./inch was supported without failure.
Fabricate semispan wing box Plan: 6/95	Establish cost effective design and manufacturing process, at least 20% cheaper and 30% lighter than the baseline aluminum structure with greater stiffness (required for 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.
Accomplished: 6/95	Stub box fabricated and shipped to LaRC for testing. Structure met ACT cost and weight goals, The basic test box was 12' by 9. Fabrication and assembly was smooth and on schedule. All NDE results indicated an excellent component and that dimensional tolerances were met.
Test semispan wing-stub box Plan: 9/95	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.
Accomplished 9/95	Stub box successfully tested to failure. Met strength, stiffness and damage tolerance goals. The box was first tested without damage and sustained all required loads. Next, it was damaged and then repaired by American Airlines personnel. Following repair, the box was loaded to failure which occurred at 143% of design limit load.

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ACCOMPLISHMENTS AND PLANS

In FY 1995. 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. Low-cost fabrication and testing of window-belt panels has produced a design that is lighter and cheaper than aluminum. This fuselage cutout was shown to take the required loads and provide a secure pressure seal. The design was so successful that Boeing has baselined it as the design of choice for cutout areas in the design of expendable launch vehicles for space applications. In the wing area McDonnell Douglas and their subcontractors along with their NASA team members manufactured and tested a wing-stub box. an inboard portion of wing structure with stiffened upper and lower panels. The stub box met ACT cost and weight goals in addition to strength and stiffness requirements. Development of a large capacity stitching machine has begun 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 automation will help meet the ACT manufacturing cost goals.

The ACT program was concluded at the end of FY 1995. The knowledge obtained from the composite wing portion of the ACT program is being transferred and continued in the composites element of the Advanced Subsonics Technology Program. The knowledge gained from the fuselage portion is being transferred to the Materials and Structures R&T Base.

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Numerical aerodynamic simulation..	46.200	48,100	38,600

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 the definition of requirements for the overall program. 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.

NAS acquires advanced systems and develops self-consistent balanced architectures that have been optimized for high-end science and engineering. These systems explore the limits of supercomputing and the design details are used as models by industxy, universities and other supercomputing centers when they purchase new systems. This takes significant risk out of major information technology acquisitions for industry, universities and other supercomputing centers.

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) research existing parallel architectures and incorporate them into future generations of NAS systems: (4) develop a hardware and software environment for prototyping and testing of computers, networks, storage devices, workstations and graphic output devices: and (5) 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 selves 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 1995. NAS had memoranda of understanding with Intel Supercomputer Systems Division, Convex, National Energy Research Supercomputer Center (NERSC), Advanced Research Project Agency (ARPA) and Sandia. Research and development with NERSC resulted in an easily ported software package enabling workload scheduling on UNIX computers called the Portable Batch System (PBS). The PBS significantly increased availability to the end users by a factor of four on several of the new computer architectures.

MEASURES OF PERFORMANCE

FY 1995 Milestones		Performance Metricg
Upgrade Local Area Network (LAN)		Increase throughput from 1 gigabit/second to 16 gigabits/second while decreasing maintenance costs.
Plan:	4/95	
Accomplished	2/95	First use of full capacity of 16 channel switch and decreased maintenance cost by a factor of 10.

FY 1996 Milestones		
Acquire and install a distributed network storage system, Mass Storage 3. that replaces the current CPU-based system with at least double the capacity.		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 lease double the current 1.6 terabyte capacity.
Plan:	6/96	
Current:	6/96	

FY 1997 Milestones

Acquire and install High-speed Processor. Plan: 3/97	Deliver to the NAS community at least a four-fold increase in computational hours.

:C(AND PLANS

The NAS program continues to create a balanced processing system through the continuous upgrade of systems and software in the areas of high-speed processing, mass storage. networks (wide-area and local), and visualization. This balanced system is required to derive the benefits of being able to numerically simulate complete aerospace vehicles systems, which include: accelerated vehicle system development cycle: critical design data that cannot be obtained from experiment but is necessary to enable new vehicle advances: reduced vehicle development cost and risk, reduced requirements for costly ground and flight testing: full aerodynamic optimization of entire vehicle systems: fully integrated vehicle designs with increased performance, safety, durability and stability: and increased vehicle operational safety.

The high-speed processors are the core component of the NAS processing system. The third high-speed processor (HSP-3), a 16-processor Cray C-90, was placed into operation in March 1993. In September 1993. its memory was upgraded from 256 megawords to one gigaword, making it the largest configured Cray C-90 in the unclassified world. During FY 1995. NAS designed. developed and implemented the 'Superhome" file system using Redundant Arrays of Inexpensive Disks (RAID) disk drives as a way to provide interim (near-term) storage. This resulted in lower storage costs for HSP-3 since 'Superhome" provided an alternative to buying high-cost proprietary disk drives from the supercomputer vendor.

Scalable parallel system technology is being advanced under the High Performance Computing and Communications (HPCC) 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.

NAS placed into operational service a High Performance Parallel Interface (HiPPI) local area network that provides high-speed system interconnect to the NAS Cray C90, HPCC IBM SP-2 parallel supercomputer, HPCC Silicon Graphics Inc. (SGI) workstation cluster, NAS mass storage system. and other multiple hosts. This local area network, which provides the path to move data off the high-speed processor as it gets computed to a mass storage system, provided a 16-times increase in aggregate throughput (from 1 to 16 gigabits per second) significantly exceeding the target goal. Later the data can be moved to high-end graphic workstations and interpreted through visualization methods developed locally, such as the Flow Analysis Software Toolkit - winner of the 1995 NASA Software of the Year Award.

During FY 1995, NAS deployed a 100 gigabyte disk array on a Silicon Graphics system. The performance measured 280 megabytes per second data transfer rate from disk to memory. Disk capacity is expected to double every year and tape capacity to increase ten-fold every four years. Over the past year the largest single UNIX file system ever configured -- one terabyte -- was

created and demonstrated. In FY 1996, 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 using low-cost small computer system interface (SCSI) disk arrays attached to an inexpensive server.

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). Research conducted at NAS to develop and validate three-dimensional numerical optimization design methods applicable to completing aircraft configurations is yielding direct inverse and numerical optimization techniques that can significantly reduce design-cycle-time for projected subsonic and supersonic aircraft. As a result, the aerospace industry has reduced aircraft configuration design cycle time by 30%, reducing the number of test cycles to two, through optimization methods and integrating these methods into the design process. Industry predicts that the elimination of another test cycle may be possible in the near future.

NAS's direct benefits to programs such as the High-speed Civil Transport (HSCT) have been the ability to determine technological and economic viability of aircraft configurations, which would have been impossible without NAS. Industry views NAS as an enabling facility to explore and implement new design methods and technology.

In FY 1996, the NAS proposal evaluation process will be re-engineered to incorporate a full peer review of all work proposed to be performed on HSP-4 and future HSPs. 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.

The high-speed processor (HSP-4) is expected to be installed in FY 1997. HSP-4 should provide at least a four-fold increase In capability over HSP-3.

	FY 1995	FY 1996	FY 1997
		(Thousands of dollars)	
High-speed research	221,300	245.500	254.300

PROGRAM GOALS

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 1,000 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 domestic HSCT will result in $200 billion in sales and 140.000 jobs for U.S. industry. As currently envisioned, an HSCT aircraft would carry 300 passengers at Mach 2.4 on transoceanic routes over distances up to 6,000 nautical miles at fares comparable to subsonic transports.

NASA is developing the technologies that industry needs to design and build an environmentally compatible and economically competitive HSCT for the 21st century. The High-speed Research (HSR) Program goal is to have the technology available to enable an industry decision on aircraft production.

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 defined HSCT environmental compatibility requirements in the critical areas of atmospheric effects, community noise and sonic boom and established a technology foundation to meet these requirements. Phase II is a cooperative program 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.

Langley Research Center, the lead center, is responsible for policy and program implementation, project planning and funding allocation. systems engineering and integration, and direct contractor interface and management. *At* the NASA Aeronautics Centers (Ames, Dryden Flight, *Langley* and Lewis Research Centers), the Center Directors provide personnel and facilities to conduct research, analysis and program management in support of the program.

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 which are managed by Lewis. The primary airframe contractors are the team of Boeing and McDonnell Douglas which are managed by Langley. The advanced flight deck contractor is Honeywell International which is 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. 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 that include:

- 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:

- The FAA/NASA Coordinating Committee provides the framework for developing and defining HSCT certification requirements: and

- The 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

FY 1995 Milestones	Performance Metrics
Verify Noise Reduction Plan: 8/95	Through an analytical combination of noise reduction concept test results. verify capability to achieve Federal Aviation Regulation (FAR) 36 Stage 3 noise rules (environmental goal).
Accomplished: 8/95	Engine/airframe tests completed and final analyses completed.
Complete Phase I Assessment of Atmospheric Impact Plan: 9/95	Completion of interim assessment of atmospheric effects of a supersonic fleet to support beginning of considerations for an HSCT emissions standard by ICAO (environmental goal).
Accomplished: 10/95	Assessment and report completed 10/95. Review by atmospheric science community external to NASA exceeded plan by a month.

Select High-Lift Concept Plan: 9/95	High-lift concept selection based on weight, low/high Reynolds number tests of 6%/2.2% models and systems integration.
Accomplished: 10/95	Wind tunnel test experienced one month delay.

FY 1996 Milestones

Select Preliminary Engine Nozzle and Inlet Designs Plan: 12/95	Selection of preliminary engine cycle, nozzle and inlet concepts based on systems analyses, aero-acoustic testing, operating cost and environmental acceptability.
Accomplished: 12/95	Two-dimensional mixer-ejector nozzle and axisymmetric Inlet selected for further technology development.
Select Airframe Subcomponent Materials Plan: 12/95	Selection of materials, processes and structural concepts for development of wing and fuselage subcomponent test articles based on material performance. producibility production costs and risks.
Accomplished: 12/95	Combination of polymeric matrix composite and titanium sandwich selected as primary and alternate wing and fuselage materials for further technology development.
Select HSCT Preliminary Concept Plan: 12/95	Selection of update reference configuration for further testing, analysis, and design.
Accomplished: 12/95	Technology concept airplane defined based on technology elements satisfies weight and mission goals.
Supersonic Laminar Flow Control (SLFC) Flight Test Complete Plan: 3/96	Complete SLFC flight experiment on F-16XL-2, acquire critical laminar flow data Over a Mach number range and altitudes for CFD code validation and SLFC configuration design code development.
Current 4/96	Minor wing glove redesign expected to result in one month slip.

Combustor Rig (Sector) Verification Tests Plan: 3/96	Verification of ultra-low NOx formation (goal: 5 grams/kilogram fuel burned) in engine combustor sector tests.
Current: 6/96	Redesign and tests of alternative combustor sector and bum through of test article expected to result in three month slip.

FY 1997 Milestoneg

SLFC Baseline Decision Plan: 3/97	Decide whether to continue SLFC technology development based on design, production and economic system integration studies resulting from F-16XL flight experiments.
Testbed Exhaust Nozzle Designed - Configuration & Materials Plan: 3/97	Complete detailed design of selected nozzle concept and release drawings for fabrication.
Flight Controller Selection Plan: 4/97	Make final determination of sidestick or wheel and column inceptor as pilot flight control mechanism.
Component Materials Selection Plan: 5/97	Select materials and structural concepts for wing & fuselage component test articles based on material performance, structural efficiency and production costs as determined by test and analysis.
Combustor Configuration Selected Plan: 8/97	Select combustor based on results of sector testing with advanced metallic and CMC liners, annular rig testing, analyses and preliminary designs of alternative combustors.
AESA Phase II (Flight Campaign Complete) Plan: 8/97	Complete *in situ* atmospheric observations with Northern Hemisphere Summer ER-2 flights.

ACCOMPLISHMENTS AND PLANS

The High-speed Research (HSR) Program continued to develop technologies to establish the viability of an economical and environmentally acceptable High-speed Civil Transport (HSCT).

In FY 1995, the first phase of the Atmospheric Effects of Stratospheric Aircraft night campaign and analysis has been completed. The NASA ER-2 high altitude aircraft, carrying a full complement of atmospheric sampling instrumentation, provided new observations to diagnose the chemistry, physics, and fluid motion of air in the low stratosphere. Enhancements to atmospheric models, which will be used to assess the potential environmental effects of a fleet of High-speed Civil Transports, have been

completed as have the emissions scenarios for a mature HSCT fleet (i.e., 1,000 aircraft]. A final report, 1995 Scientific Assessment of the Atmospheric Effects of Stratospheric Aircraft. has been completed and is being printed as a NASA publication.

Wind tunnel testing, computer analyses and fflght simulations were completed last year to verify the capability of a HSCT to satisfy the Federal Aviation Regulation (FAR)36 Stage 3 noise standards. Research efforts have shown that the standards may be achievable with a combination of engine cycle and nozzle designs, high lift devices, and specialized operational procedures. The High-Lift Engine Aeroacoustics Technology (HEAT) tests of a 13.5% scale model, including hot engine, noise-suppression nozzles and high lift wings that were conducted in the Ames Research Center 40-by-80 foot wind tunnel were completed. Initial results confirm previous computer predictions that the combination of devices may satisfy stringent noise standards and provide the necessary aircraft performance characteristics.

Research and testing continued in FY 1995 on advanced, lightweight composite materials which could be used as exhaust nozzle acoustic liners to further enhance noise attenuation. The acoustic performance of the candidate materials, measured in test cells, indicates that an additional 3 to 4 db reduction in total jet noise is achievable by use of these liners. Airport community noise studies have been completed which evaluate the impact of HSCT advanced takeoff procedures on community noise. Aircraft loudness patterns at several noise sensitive major international airports have been estimated based on projected aircraft and airport operations.

The requirements definition activity for Flight Deck Systems was also completed last year. Airplane Operational Requirements. HSR Flight Deck Systems Requirements. and Functional Capability Documents were all developed, reflecting HSR goals of all-airport/all-weather takeoff and landing capability and no drooped nose. Testing of night Deck External Vision Systems demonstrated the capability to 'tile' together multiple external video camera views into a single, wide field-of-view pilot display providing the required forward visibility during takeoff and landing to avoid the drooped nose. Also, extensive piloted simulation has been completed. demonstrating good handling qualities.

Technical perfoxmance requirements for individual airframe materials were defined as were loads criteria for the wing and fuselage structures. Extensive strength and durability testing of titanium composite and polymeric matrix composite materials was conducted and the performance and characteristics of these candidate airframe materials was determined.

The Tu-144 Flight Research Project, to conduct supersonic civil aviation flight tests, with Tupolev Design Bureau progressed very well in FY 1995. Design reviews of aircraft modifications and experiments were conducted by a joint U.S. and Tupolev team. Installation of upgraded replacement engines, electrical systems, and test instrumentation and recorders is near completion. Flight test plans for aircraft checkout and research flights have been developed and the flight crew has been selected and is in training.

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, producibility. production costs and risks. Selection of a preliminary airframe concept will be based upon projected capability to achieve Phase II program goals and impact on sonic boom. performance and weight. Selection of preliminary engine cycle, nozzle and inlet designs will be made 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 11 program goals of NOx emissions of 5 gm/kg fuel burned and FAR 36 Stage III noise requirements. Each of the requirements definitions, assessments and preliminary design selections will be integrated and a selection made of the HSR Technology Concept Airplane, a major program milestone. The selected concept will become the updated HSR 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 CFD code of SLFC configurations.

In FY 1997, the HSR Program plans to complete the detailed design of the testbed exhaust nozzle concept. Design drawings will be released to begin fabrication of the nozzle, which when completed will be fitted to and tested with the selected testbed engine. The selection of the core engine combustor will also be made, based upon results of completed sector testing wlth advanced metallic and ceramic matrix composite liners: annular rig testing: manufacturing assessment: and analyses and preliminary designs of two alternative combustors. The p r o m will also select the materials and structural concepts that will be used to develop the component test articles of the wing and fuselage. Concept selection will be based upon materials performance. structural efficiency, and production costs as determined by testing and analysis. The Atmospheric Effects of Stratospheric Aircraft (AESA) flight campaign will conclude. Final sampling of the stratosphere in the Northern Hemisphere by NASA high-altitude aircraft will be completed as a precursor for the Anal assessment of high-speed civil transport environmental compatibility.

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Advanced subsonic technology	125.800	169,800	187,200

PROGRAM GOALS

NASA's role in civil aeronautics is to develop technology to ensure that the U.S. industry is prepared to meet the demands and increasing constraints being placed on the aviation system by new safety requirements. increasingly stringent noise and emissions standards, and growing air traffic volume. These constraints slow the introduction of new technology due to the increased risk and cost of the application of technology to improve aircraft performance and international competitiveness. The goal of NASA's Advanced Subsonic Technology (AST) program is to develop high payoff technologies, in cooperation with the Federal Aviation Administration (FAA) and the U.S. aeronautics industry, to benefit the civil aviation industry and the flying public by increasing safety, reducing civil aircraft impact on the environment, increasing the capacity of the airspace system, and insuring that new technology development is compatible with those primary objectives. Success will be measured by how well NASA contributes to technology readiness that will enable a larger share of the world market for civil aircraft to be captured by U.S. manufacturers and to the effectiveness and capacity of the national air transportation system.

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. worldwide 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. Also, more stringent noise curfews and engine emissions standards are expected before the end of this centuxy.

STRATEGY OR 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: terminal area productivity (TAP), short-haul aircraft, noise reduction, propulsion. environmental assessment, and fly-by-light/power-by-wire (FBL/PBW). An ad hoc management review team, comprised of industry and governmental representatives. provided strategic oversight during the developmental stage. Industry is invited to review progress on a continuing basis to insure that the program continues to meet those needs. The 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 TAP element was expanded to include development of technologies critical to the next generation airspace system to greatly enhance the efficiency and productivity of aircraft/airspace operations for all users.

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 element 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 ellmination 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 Me 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. This will 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 of the aerospace industry. 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 1992 state-of-the-art by the year 2000 for future subsonic transports. The approach is designed to develop noise reduction technology for engine source noise, nacelle aeroacoustics. engine/airframe integration, interior noise, and flight procedures to reduce airport community noise impact. 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 (TAP): 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, enhance terminal air traffic management, improve low-visibility landing and surface operations, and integrate aircraft and air traffic systems while maintaining safety.

In 1996. in cooperation with the FAA. the objectives of the TAP element are being expanded to include development of critical air traffic technologies Advanced Air Transportation Technology (AATT) which will enable a revolutionized U.S. air traffic capability and the development of 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 will use its expertise in aircraft human factors and automation technologies to develop and validate high risk technology elements of the 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.

Integrated Wing Design: Currently, the U.S. commercial transport aircraft manufacturing industry is focused on reduced costs and improved time to market through reduced product development cycle time. In cooperation with U.S. industry, NASA is developing efficient, integrated design and test procedures focused on streamlined aerodynamic design cycle times reduced by 50%. This will provide an overall reduction in the total aircraft development time of one year compared to an established 1995 baseline product development cycle time. In addition, the new design and test procedures will be used to deliver validated, highly efficient wing designs for cruise and low-speed operation which include the effects of propulsion system integration. This will yield a 4-percent reduction in Total Airplane Related Operating Costs (TAROC) relative to established 1995 baseline technology levels. Exit strategy Includes final validation of cycle time and TAROC objectives by the U.S. industry. Finally, it is anticipated that the validated design and test procedures will enable industry to rapidly implement technology delivered by other AST elements, leading to a 10 to 15 percent overall improvement in TAROC over the baseline.

Propulsion: In cooperation with the U.S. industry, NASA is developing propulsion technology with the objectives of reducing the environmental impact of future commercial engines through reduced combustor emissions and increasing the competitiveness and market share of the U.S. propulsion industry. The goals of this element are to reduce nitrogen oxide emissions by at least 70% for large engines and 50% for regional engines over 1996 International Civil Avionics Organization (ICAO) Standards and improve the direct operating cost (DOC) by 3% for large engines and 5% for regional engines with fuel efficiency improvements of 8 to 10%. Research and development focuses on low emission combustors; affordable advanced turbomachinery; high temperature disk and blade materials; improved controls and accessories: advanced propulsor mechanical components; and light weight, affordable engine static structures. Aerodynamic, aeroelastic, and cooling analytical models and computational tools are being developed and validated using affordable advanced turbomachinery components (which is expected to result in a 30% reduction in development time and manufacturing cost of cooled airfoils) and engine testing. The products of this element will be incorporated into the next generation of very high bypass ratio commercial engines 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 civil aviation annually. However, annual U.S. production of general aviation aircraft has fallen to approximately 5% of the 1978 level. In cooperation with U.S. industry through a 50/50 cost-share venture, NASA seeks to support revitalization of U.S. general aviation through development and deployment of advanced technologies for enhanced small aircraft transportation system capabilities. Technologies are targeted which improve the utility, safety, ease-of-use, reliability, environmental compatibility, and affordability of the next generation of general aviation aircraft for business and personal transportation. Key enabling technologies include satellite navigation. flat-panel displays, small computers, expert systems, digital data link communications, low-cost manufacturing, and ice protection. By reducing the cost of manufacturing aircraft and the 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.

Short Haul [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, and focuses on 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 decibels A-weighted (dBA) Over current technology. Complex flight profiles involving steep approach angles and multi-segmented approach paths 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.

Technology Integration & Environmental Impact: Technology Integration allows for a full understanding of 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 Impact develops 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).

Environmental Research Aircraft and Remote Sensor Technology (ERAST): The objective of ERAST is to support the Environmental Impact Element by developing sensors needed to perform atmospheric observations to determine the chemical and physical characteristics of the atmosphere relative to possible effects of aircraft chemistry (i.e., primarily ozone) and climate. The sensors will be used aboard the NASA DC-8 flying laboratory during field campaigns.

Composites: The aircraft industry's resistance to using composites is related to economics and reparability/maintainability. While the current demonstrated level of composites technology can promise improved aircraft performance and lower operatlng costs through reduced structural weight, it does so with increased manufacturing costs. currently twice the cost of aluminum. The program goal is full-scale verification of affordable composite primary wing structures with an additional goal of demonstrated structure robustness through simulated service experience and repair by airline personnel. The primary objectives of the composites element are to reduce the weight of civil transports by 10 to 30 percent and their acquisition cost by 10 to 20 percent

compared to today's metallic transports. This translates into a potential 5 percent reduction in total aircraft-related operatlng costs (TAROC) 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.

MEASURES OF PERFORMANCE

FY 1995 Milestones	Performance Metrics
Short Hau1(General Aviation): Execute Joint Sponsored Research Agreement (JSRA). Plan: 12/94	Establish and implement cost-sharing alliance with industry, non-profit organization and government agencies based on the JSRA mechanism for commercialization focus.
Accomplished: 12/94	Established JSRA, FAA, Industry Advanced General Aviation Transportation Experiments (AGATE) consortium, Executive Council (Board of Directors) and four Work Package Technical Councils. Achieved program consensus by industry participants.
Fly-By-Light/Power-By-Wire: Fiber Optic System Design. Plan: 6/95	Complete fly-by-light (FBL) flight control system design for advanced civil transports providing the basis for subsystems to be flight tested on transport systems research vehicle.
Accomplished: 6/95	Simulations/analysis found FBL architecture to be safe with dynamic performance equivalent to most modem airplane (fly-by-wire)control systems. Technical analyses of evaluated architectures and FBL system requirements documented.
Terminal Area Productivity: Develop two dimensional unsteady model of aircraft laminar wake vortex systems. Plan: 6/95	Validate atmospheric model that reproduces the transport and decay of wake vortices near the ground through night evaluations conducted during field deployments at airports.
Accomplished: 6/95	provided limited validation of two-dimensional wake vortex model and supporting simulations. Presented to the FAA a recommended interim matrix approach of wake vortex separation by aircraft classification. Advance Vortex Spacing System (AVOSS) concept defined in a NASA report.

FY 1996 Milestones

Short Haul (Civil Tiltrotor): Complete flight acoustic database complete. Plan: 12/95	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.
Current: 12/95	Comprehensive flight acoustic database acquired for XV-15 aircraft, including conventional and step approach paths. Sufficient flight acoustic data acquired for V-22 to enable scaling law validation.
Propulsion: Complete 60 Atmosphere Combustion Test Rig. Plan: 3/96 Current: 3/96	Operate national facility for testing large engine sector combustors and full annular combustors for regional engines.
Aging Aircraft: Verify methodology to predict the residual strength of airframe structures. Plan: 6/96 Current: 6/96	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.
Composites: Document wing configuration requirements. Plan: 12/96 Current: 12/96	Robust composite wing design that meets all requirements, cost, and weight targets.
Noise Reduction: Validate concepts for 3-decibel fet and fan noise reduction relative to 1992 technology. Plan: 9/96 Current: 9/96	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).

Integrated Wing Design: Establish swept wing suction panel design criteria. Plan: 6/96	Establish hole size, spacing and orlentation for optimized suction requirements for laminar flow aircraft.
Current: 9/96	This element has been rephased. resulting in a three month delay in completing this milestone.
Environmental Assessment: Atmospheric observations from DC-8 Flying Laboratory. Plan: 9/96 Current: 9/96	Gather data from first *in situ* observations dedicated to subsonic scientific assessment to address effectsof contrails on earth's radiation, potential effect of aircraft soot or sulfate.

FY 1997 Milestones

General Aviation: Define GA transportation system operational, functional and performance requirements. Plan: 12/96	Define and publish *small* aircraft transportation system requirements for users, aircraft and infrastructure.
Technology Integration: Release first generation aviation system analysis capability. Plan: 12/96	Deliver a computerized process that provides AST management with easy access to analysis and data bases for identifying potential benefits of AST technologies.
Integrated Wine Design: Mid-term assessment of impact on TAROC and design cycle time compared to the baseline configuration. Plan: 9/97	Evaluation of technology improvements vvill result in at least 1% improvement in TAROC and 20% improvement in aero design cycle time.

ACCOMPLISHMENTS AND PLANS

Fly-By-Light/Power-By-Wire: In FY 1995. four fly-by-light (FBL) aircraft control architecture concepts were evaluated via simulation and analysis to assess safety issues, databus configurations, and life cycle costs. One architecture was selected for continued development. The selected architecture was determined to be safe, with performance equivalent to the most modem airplane fly-by-wire control systems. In FY 1996, the detailed design of the selected power-by-wire (PBW) system will be completed for a two engine civil transport. The electromagnetic environment modeling code will be validated using results from Transport Systems Research Vehicle (TSRV) flight tests. A preliminary flight test assessment of the integration of basic FBL components will

be completed and provided to industry. The results will be incorporated in the commercial transport verification and validation plan. In FY 1997, electromagnetic assessment methods will be validated using previously flight tested FBL control subsystems. In preparation for future FBL/PBW flight demonstrations on the aileron of the TSRV, electrical actuators will be fabricated and integrated with FBL control to demonstrate performance superior to hydraulic actuators.

Aging Aircraft: During FY 1995, three nondestructive evaluation (NDE) prototype instruments for crack detection were developed and verified on test samples to provide a choice of detection methods. An optical system for crack detection was determined to be not viable. and a rotating head eddy current probe was developed instead. In FY 1996, the analytical tools to predict the residual strength of a fuselage with widespread fatigue damage and accidental discrete source damage will be experimentally verified through large-scale panel testing in cooperation with industry. After verification and subsequent refinement, the codes will be provided to industry. Starting in FY 1996 and continuing through FY 1997, field testing and refinement of signal processing techniques for all of the prototype NDE systems will be conducted. At the same time, technology transfer and commercial product licensing agreements for the NDE technology will be pursued.

Noise Reduction: In FY 1995, simulations demonstrated that adaptive noise control (ANC) varies the absorbative characteristics of an acoustic liner to optimize its performance for different engine operating conditions. A 20 dB noise reduction was demonstrated at a single frequency. This indicates that ANC is a viable noise reduction concept with significant reduction of technical risk In FY 1996, experiments will be conducted on concepts to improve nacelle duct noise treatment effectiveness. Testing will be completed on concepts for jet and fan noise reduction. Other activities include the selection of an active noise control concept for engine demonstration: the completion of an engine noise database: the release of the community noise impact model; and a demonstration of an active structural acoustic control on a business aircraft. In FY 1997, the most promising low noise concepts for fan/jet/core will be selected based on advanced acoustic analyses and model tests. Additional planned work includes validating passive and adaptive linear treatment models; modeling and quantifying the flap edge noise source; and demonstrating active control of boundary layer induced interior noise.

Terminal Area Productivity: In FY 1995, installation of an existing simulator and associated computer systems on the TSRV began in preparation for future flight tests. To improve airport capacity, two-dimensional laminar wake vortex models were developed and partially validated. This resulted in a recommendation to the FAA for an interim matrix approach of wake vortex separation according to aircraft classification. 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 was completed. In FY 1996, a flight demonstration of integrated airport surface automation concepts will be conducted to identify inter-system issues between Global Positioning System (GPS), radar and other surface movement technologies. In FY 1997, cockpit systems flight tests will be performed for landing, roll out, take-off and taxi to develop algorithms. displays and data bases for control systems to minimize runway occupancy time. The cockpit systems flight tests will be performed to demonstrate the Taxi-Navigation And Situation Awareness (T-NASA) System to assist the crew in maintaining (or improving) the safety and efficiency of taxi operations in visibility down to 300 feet runway visual range. T-NASA is a 3-component system comprised of an electronic moving map display, a head-up perspective taxi display, and a 3-D audio alert system, being developed to provide navigation and situation awareness information in the flight deck for taxi on the airport surface.

External studies to stimulate the search for new ideas and concepts. to develop key technology accelerators such as conflict probes, and to conduct cost-benefit analyses were initiated in FY 1995. The results of these efforts are being used to guide the development of the program plan for the Advanced Air Transportation Technology (AATT) program. In FY 1996. the AATT effort will begin 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. In FY 1997, analyses, simulations. and experiments will be conducted to quantify the probability of conflicts, define requirements, and accelerate the development of conflict-probe and other technologies to prepare for their evaluation under a future field deployment at an FAA Air Route Traffic Control Center.

Integrated Wing Design: In FY 1995, the analysis of the aerodynamic design cycle was completed and an industry baseline was established for performance measurement. Top level Integrated Wing Design element objectives were defined as: (1) a fifty percent reduction in the aerodynamic design cycle time which leads to a one year reduction in the overall development cycle, and (2) a four percent reduction in TAROC compared with the baseline. Technical requirements to meet these objectives were defined to provide maximum reduction on cycle time and TAROC for the established baseline. The high Reynolds number test phase on the ten foot chord hybrid laminar flow control (LFC) swept wing was also completed on time and within budget. Near real-time data transfer to the U.S. industxy partners was accomplished. Also, the final design review for the high wing transport scale model was completed, and a project plan was developed for the FY 97 test program which will establish Reynolds number effects on the high-lift performance of externally blown flaps (EBF). In FY 1996, analysis of the LFC database by a NASA/Industry team for establishment of swept-wing suction panel design criteria for a future, low-drag laminar flow aircraft design will be conducted. Model fabrication of the EBF will be completed in preparation for FY 1997 wind tunnel testing. In FY 1997, a low-speed pressure sensitive paint (PSP) diagnostic and preliminary load system to significantly reduce wind-tunnel test cost and an integrated computer aided design/computational fluid dynamics (CAD/CFD) grid generation scheme to reduce computational process time will be developed. Inverse pylon/nacelle design tools will be available to incorporate new engine installations on existing wings. Reynolds number effects for EBF will be established in order to develop simpler high-lift systems at current performance levels. U.S. aircraft manufacturing industry will conduct a mid-term assessment on progress toward reduced cycle time and TAROC objectives.

Propulsion: In FY 1995, critical and enabling technologies were identifled for 2005 propulsion systems for large and regional engines, based on contributions to improvements in future emissions and noise standards, SFC, and direct operating cost plus interest. In FY 1996, a new and unique high pressure and high temperature Advanced Subsonic Combustor Rig will be checked-out and readied to provide valuable assessments of low emission combustors for advanced engines. The combustor rig will significantly improve the U.S. capability in cumbustor testing by providing a capability to operate at pressures in excess of 50 atmospheres, temperatures of more than 3000'F, and airflows of 38 pounds per second. The first test is scheduled to evaluate a lean direct injector low emission combustion concept for future aircraft engines. In FY 1996, aerodynamic, aeroelastic, and cooling technology will be aimed at developing and validating industry's affordable advanced turbomachinery. Technology development efforts will be initiated for advanced propulsor mechanical components, controls, and materials. In FY 1997, extensive screening tests of advanced low emission combustor concepts for both large and regional engine applications will be conducted.

Short Haul (General Aviation/Commuter): During FY 1995. the Joint Sponsored Research Agreement (JSRA) for General Aviation/Commuter Alliance between NASA, the FAA. and several U.S. small airplane manufacturers and suppliers was initiated. The Executive Council (Board of Directors) was established. Four Work Package Technical Councils and the Executive Council achieved program consensus with industry participation. 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 was completed. In FY 1996, the computer operating architecture for future general aviation 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 general aviation aircraft will be developed. In FY 1997. the transportation systems operational, functional and performance requirements will be defined and published for users, aircraft and infrastructure.

Short-Haul (Civil Tiltrotor): In FY 1995, analytical and experimental studies of several civil tiltrotor rotor noise reduction concepts were completed. Displays and pilot-to-cockpit interfaces for low noise approaches of the civil tiltrotor were identified. Comprehensive simulation of one engine inoperative operating procedures was completed on the vertical motion simulator. During FY 1996, the design and fabrication of several scale model low-noise proprotor concepts will be completed in preparation for wind tunnel testing in FY 1997. In early FY 1996, a comprehensive flight acoustics database was acquired for XV-15 aircraft, including conventional and steep approach paths. This flight database of ground noise footprints will be used to develop low noise approach profiles that provide a 6 dBA reduction over conventional approaches, and will be used as inputs to the Vertiport Noise Impact model. Also, an investigation of low noise flight procedures will begin in the vertical motion simulator, and contingency engine power concepts will be selected for preliminary design. In FY 1997, the noise reduction provided by the low-noise proprotor concepts will be evaluated through wind tunnel testing and the isolated rotor configuration database will be completed to validate the blade vortex interaction prediction code. During model scale testing, multiple proprotor concepts, to be developed by several of the U.S. rotorcraft manufacturers, will demonstrate noise reduction of 6 dBA. From this database of rotor tests. concepts will be selected for more extensive full span testing. Also in FY 1997, the initial evaluation of low noise approach profiles will be completed.

Technology Integration & Environmental Impact: Under the area of Technology Integration, a report was delivered in FY 1995 describing the average direct operating cost savings (3.5% to 5%). average fuel burn savings (18%), and average takeoff weight reduction (9%) as new subsonic transports with advanced engines are introduced into the commercial fleet. In early 1996, a quick response report server was established on the Internet to provide a single, integrated source of data needed to perform aviation system analyses. The incremental development of the aviation system analysis capability will continue with the development of an executive architecture and the economic analysis module. In FY 1997, the first generation Aviation System Analysis Capability (ASAC) will be released. ASAC is envisioned primarily as a process for understanding and evaluating the impact of advanced aviation technologies on the U.S. economy. ASAC will consist of a diverse collection of models, data bases, and analysts from both the public and private sectors brought together in varying combinations to work issues of common interest to NASA and other organizations within the aviation community. ASAC will provide this support through information system resources, models and analytical expertise, as well as through its role as a conductor and organizer of large-scale studies of the aviation *system* and advanced technologies.

In the area of Environmental Assessment, a computational capability was developed in FY 1995 for analysis of the chemical processing which occurs in the mixing of engine exhaust with the background atmosphere. Exhaust trace chemistry for operational engines was measured and instrument calibrations were validated for a small number of engine operating conditions. The first program level assessment report on the atmospheric impact of subsonic aviation will be completed in FY 1996, leading to participation by principal investigators in preparation of 1997 United Nations Environment Program/World Meteorological Organization (UNEP/WMO) ozone assessment report. Data that was analyzed from the first in situ atmospheric observations will be released and a fundamental study of combustion product interaction will be completed in FY 1997.

Environmental Research Aircraft and Remote Sensor Technology: In FY 1995, instrument development in support of the field campaigns aboard the NASA DC-8 Flying Laboratory was initiated. In FY 1996, the first in situ atmospheric observations dedicated to subsonic aviation assessment will be performed aboard the DC-8 flying laboratory to perform climate related measurements. The second field campaign with the DC-8 flying laboratory will make ozone chemistry measurements to characterize sources of reactive nitrogen in frequently traveled regions and the effect on ozone will also occur in FY 1997.

Composites: In FY 1995. the composites element was 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. 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. In FY 1997, a robust manufacturing plan for the production of multiple composite components that meet all cost and weight goals and a structural development plan will be developed. Manufacturing equipment will be fully operational, fabrication and assembly processes will be defined, and manufacturing cost allocations will be revised demonstrating the capability to fabricate and assemble composite wings below the cost of conventional aluminum wings.

BASIS OF FY 1997 REQUIREMENT

CONSTRUCTION OF FACILITIES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Aeronautical facilities revitalization			
Modernization of unitary plan wind tunnel (UPWT) complex (ARC)	22,000	--	--

PROGRAM GOALS

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

The Aeronautical Facilities Revitalization program that began in FY 1988 will be completed with the Implementation of the final phases of the Unitary Plan Wind Tunnel (UPWT). 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 facllity 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 facllity. These upgrades and revitalizations will provide the U.S. with the wind tunnel infrastructure needed to help maintain world leadership in aeronautics.

FY 1997 Milestones	Performance Metrics
Complete Unitary Piping Refurbishment & Cooling Tower Replacement - 11/96	Complete construction on schedule. within budget and meeting requirements.
Complete Unitary 7.2 kV Switchgear Replacement, Weld Repairs, and Main Drive Speed Control Replacement- 1/97	Complete construction on schedule. within budget and meeting requirements.
Complete Unitary 11-Foot Flow Quality Improvements - 4/97	Complete construction on schedule, within budget and meeting requirements.

ACCOMPLISHMENTS AND PLANS

The UPWT modernization project will continue during FY 1996 and FY 1997 with work on the automation. flow quality, piping, pressure vessel, and control room work packages. The project is scheduled to be completed in 1999 at an estimated cost of $60.4 million. The funding required to complete this project is currently under review. If additional funding is required, available FY 1994 aeronautical construction resources will be redirected to this project in accordance with the provision in the FY 1996 Conference Report accompanying H.R 2099.

BASIS OF FY 1997 REQUIREMENT

NATIONAL AERONAUTICAL CII

	FY 1995		FY 1997
		(Thousands of Dollars)	
t s fa lt :	35,000	--	--

ACCOMPLISHMENTS AND PLANS

' Administration has decided not to pursue development of the a c Tunnel Complex (NWTC), given g constraints for the foreseeable future. By March of 1996, the National Wind Tunnel Project Office at Lewis h Center will l a Systems gn Review (SDR) as a means of finalizing tunnel design work conducted to d After completion of the SDR, t Project Office will archive collected data and begin an orderly phase-down of tl program. At the conclusion of these activities, *any* remaining funds ll or p to be grammed.

Space Access
and Technology

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE ACCESS AND TECHNOLOGY

SPACE ACCESS AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	Page Number
		(Thousands of Dollars)		
Advanced space transportation	162.100	188,500	324,700	SAT 5-4
Spacecraft and remote sensing	174.900	174.100	151,000	SAT 5-13
Advanced smallsat technology	61.900	39.100	30.000	SAT 5-26
Space processing	33.300	54,000	41.800	SAT 5-29
Flight programs	3.500	8.800	--	SAT 5-38
Commercial technology programs	33.800	27.400	24,200	SAT 5-39
Technology transfer agents	12.000	17.100	7.300	SAT 5-42
Advanced concepts	[3,000]	6.600	3.800	SAT 5-45
Small business innovation research programs	123.900	125.700	142.200	SAT 5 4 7
Total	605.400	641.300	725.000	
Distribution of Program Amount by Installation				
Johnson Space Center	24,600	34,600	25.400	
Kennedy Space Center	5.900	6.300	7.100	
Marshall Space Flight Center	149.900	185.800	318.600	
Stennis Space Center	17.700	20.100	19.700	
Ames Research Center	31.500	29.900	41.300	
Dryden Flight Research Center	600	4,400	6,800	
Langley Research Center	56,600	49.300	50,800	
Lewis Research Center	55.700	64,800	54,100	
Goddard Space Flight Center	35.200	36.500	33.100	
Jet Propulsion Center	69,000	69.600	60,600	
Headquarters	158.700	140.000	107.500	
Total	605.400	641.300	725.000	

OFFICE OF SPACE ACCESS AND TECHNOLOGY

SPACE ACCESS AND TECHNOLOGY

PROGRAM GOALS

The goal of the Space Access and Technology program is to pursue, in a partnership between 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 to improve 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.

STRA FOR ACHIEVING AL

The Space Access and Technology program has three 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 demands improved instrument detector technologies to optimize sensitivity and resolution across the electromagnetic spectrum. Lowering space mission costs requires demonstration of a new paradigm in spacecraft design-to-launch by reducing spacecraft cost 50% by 1997, reducing operations cost 30% 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 in 1996. The network will give entrepreneurs access to 100% of current, non-sensitive technology activities and opportunities.

BASIS OF FY 1997 FUNDING REQUIREMENT

ADVANCED SP ORT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Reusable launch vehicle - systems engineering & analysis	3,800	500	--
Reusable launch vehicle - technology program	75.500	49,500	--
Reusable launch vehicle - initial flight demo prog (FDP)	49.200	109,000	266,100
Advanced space transportation technology *	--	--	42,000
Transportation technology support	33,600	29,500	16,600
Total.....	162,100	188,500	324,700

- Advanced Space Transportation Technology efforts are also supported by $15 million in FY 1996 and $12 million in FY 1997 funded within the Engineering and Technical Base program of the Office of Space Flight.

PROGRAM GOALS

The Advanced Space Transportation program goal is to develop new technologies aimed at revitalizing access to space. These new technologies are targeted to reduce launch costs dramatically Over the next decade, to increase the safety and reliability of current and next generation launch vehicles, and to establish new plateaus of performance for in-space propulsion while reducing cost and weight.

STRATEGY FOR ACHIEVING GOALS

Reusable Launch Vehicle (RLV)

In accordance with National Space Policy, NASA is taking the lead in developing the technology for the next generation reusable space transportation system. The program will include concept analysis, ground-based technology development, and a series of flight demonstrators (the DC-XA, the X-34 Small Reusable Demonstrator and the X-33 Large-Scale Advanced Technology Demonstrator). Each portion of this program contributes to the process of validating key component technologies, proving that the technologies can be integrated into a functional vehicle, and demonstrating the required operability to make low-cost access to space a reality.

NASA is utilizing an innovative management strategy for the Reusable Launch Vehicle program, based on industry-led cooperative agreements. As a result of industry's leadership of the program, the participants are not playing traditional roles, with government overseeing and specifying the work of the industry contractors. Instead. government participants are acting as partners and

subcontractors, carrying out tasks chosen by the industry team leaders based entirely on their determination that government personnel and facilities offer the most cost-effective means to accomplish the tasks. The government participants report costs and manpower to the industry team leader as would any other subcontractor.

The industry-led cooperative arrangement allows a much leaner management structure, lower program overhead, and increased management efficiency. NASA will have a maximum management staff of only 20 for the RLV, and other government personnel working on the X-33 program work on specific tasks selected by industry team leaders. When an assigned task is completed, government personnel not part of the management staff will either receive another tasking selected by industry, or move on to other, non-RLV duties.

Each current partner on the X-33 program is contributing manpower, facilities, and funds to the technology development effort. Moreover, NASA's payments to industry are dependent on completion of milestones specified in the cooperative agreements. Cost-sharing will continue under all new cooperative agreements signed for the RLV program, although the actual shares will depend on industry proposals to be submitted and subsequent negotiations.

As directed in the National Policy, the X-33 program will face two major decision points, one in 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 full-scale development of an operational RLV will be pursued. Each of these decisions will be based on specific programmatic, business planning and technical criteria which have been agreed between NASA, the Office of Management and Budget, and the Office of Science and Technology Policy. The release of outyear 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. The distribution of RLV funds by activity is dependent on the X-33 concept(s) to be selected in 1996. As a result, no detailed breakout of the RLV budget has been provided with this submit. These details will be provided as part of the package sent to the Administration to request approval to proceed with Phase 2 of the X-33 program.

Advanced Space Transportation Technology

The Advanced Space Transportation Program's primary objective is to complement the RLV in reducing the cost of space transportation by orders of magnitude. NASA is implementing a strategic architecture that focuses the development of space transportation technology on advanced Earth-to-orbit (ETO) and advanced in-space transportation. The advanced ETO technology includes near-term, low-cost transportation technologies driven to provide industry the tools to achieve dramatic reductions in the cost of boosting small payloads into orbit. The program also includes highly advanced Earth-to-orbit technology targeting space transportation developments that can reduce transportation cost to LEO by an order of magnitude below the RLV target. Propulsion technologies would concentrate on combined conventional rocket and air-breathing propulsion. A combined propulsion system such as the rocket-based combined cycle (RBCC) takes advantage of air-breathing propulsion efficiency. These types of propulsion systems have the potential to approach airline operability and greatly simplify the overall vehicle system. The in-space transportation effort includes revolutionary chemical and non-chemical technology to enable low cost orbit transfer for Earth-orbiting satellites and to provide high-energy, light-weight propulsion for deep space exploration missions. The objective is

to demonstrate technologies that substantially reduce the size and mass of in-space transportation and reduce the trip times required for exploration missions.

NASA will consider outyear funding for the highest priority. most promising projects based on findings in FY 1996 and FY 1997. as well as on the availability of funds.

Transportation Technology Support

In addition to the RLV, the National Space Transportation Policy calls on NASA to support other agencies and technologies to enhance all means of access to space. The Transportation Technology Support budget element funds a variety of efforts to reduce the cost and improve the reliability, operability, responsiveness and safety of advanced launch systems, particularly hybrid rocket motors and spacecraft propulsion systems. 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. The programs funded in FY 1997-01 within the Transportation Technology Support budget line are the Hybrid Propulsion Demonstration program, In-Space Transportation and Engineering Capability Development.

The Solid Propulsion Integrity Program (SPIP) was transitioned to the Hybrid Propulsion Demonstration Program (HPDP) during late FY 1995 and early FY 1996. Many of the SPIP products, personnel expertise, and industrial organizations are being transitioned into the HPDP. The HPDP is being conducted under a Cooperative Agreement between NASA, DoD and U.S. Industry, with the objective of demonstrating that hybrid propulsion technology is mature enough to enable US industry to commercialize hybrid boosters for space launch operations. Hybrid motors offer high potential for safer, lower cost, and environmentally friendlier boosters for U.S. launch providers. Hybrid motors can be throttled, shut down and restarted and they produce no chlorine or aluminum exhaust products. The HPDP is a resource-shared (experts, facilities and dollars) and jointly managed program that will demonstrate full-size, flight-like boosters on a schedule suitable for application on expandable launch vehicle (ELV)'s and reusable launch vehicle (RLV)'s early in the 21st century. As with the RLV program, payment of a fixed amount of government funds is dependent on completion of specified milestones throughout the program. The completion of the HPDP in FY I999 is designed to allow easy, rapid development of flight hardware with minimum risk.

The In-Space Transportation technology program is worklng to develop and demonstrate major advances in very high-performance in-space propulsion systems. These systems will reduce launch costs by reducing the weight of space transfer propulsion systems. JPL and LeRC are working with OSAT and the Office of Space Science on a flight experiment to validate the technology for an ion propulsion in-space transfer system. Life and performance of the system will be demonstrated both on the ground and in space, with a launch tentatively planned for FY 1998 on a New Millennium satellite. The in-space tests of this industry-produced ion propulsion unit will also provide data to address issues with system/spacecraft integration, control accuracy and space plasma interactions. The In-Space program also funds long-term, university-based analysis and experimental assessments of critical technology issues for very advanced propulsion and power concepts to enable a broad class of future exploration missions.

The Engineering Capability Development element provides resources for utilization. maintenance, and productivity upgrades of 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 RLV configurations will require 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.

Funding for Expendable Launch Vehicle Cooperative Tasks and Operations/Software Technologies ends in FY 1996. However. NASA will continue to support DoD as lead agency for ELV improvements in areas where NASA's unique facilities and expertise can help the government and industry. Moreover, improvements to launch operations are an integral part of the RLV program.

MEASURES OF PERFORMANCE

Release of the Cooperative Agreement Notices for the X-33 and X-34 Plan: January 1995 Accomplished: 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 man: February 1995 Accomplished: 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.
Apply second generation arc jets for commercial satellite station keeping man: September 1995 Accomplished: September 1995	First generation systems were commercially deployed in 1994. Qualification-level tests of second generation arc jets will be conducted with industry participation. The system will be baselined for next generation satellites.
Complete Advanced Space Transportation Technology Roadmaps and publish program plan. Plan: April 1996 Current: April1996	Advanced Space Transportation Technology initiative focuses on developing advanced Earth-to-orbit and in-space transportation capabilities. Roadmaps and plans will prioritize these next-generation efforts.

Get approval to proceed with the X-33 ATD Plan: July 1996 Current: July 1996	The decision will depend on achievement of detailed criteria for measuring the readiness of the RLV program to proceed with the X-33 Advanced Technology Demonstrator.
Cooperative ELV Tasks: - Test AI-Id cryogenic tank segment to failure - Demonstrate end-to-end electro-mechanical actuator - Demonstrate advanced diagnostic tools Plan: September 1996 Current: September 1996	These advanced technologies that reduce costs, enhance reliability and/or improve payload performance will transition to the industry partners for application to both reusable and expendable launchers.
Complete first flight-ready solar electric flight system design Plan: September 1996 Current: September 1996	System weight, size. and cost targets must be met. A cooperative flight demonstration experiment will be initiated.
Advanced Space Transportation Technology Awards Complete Plan: September 1996 Current: September 1996	Initial efforts are expected to focus on technologies for low-cost boosters in the 100-kg-class, Rocket-Based Combined Cycle (RBCC) engines and high-energy in-space transportation.
Fly First Hybrid Sounding Rocket Plan: 1st Qtr. FY 97	Fixed-price milestone payment depends on flight occurring on schedule.
Ground Test Hybrid 250K Motor Plan: 2nd Qtr. FY 97	Fixed-price milestone payment depends on test occurring on schedule.
Complete development of second generation (longlife) ion thruster night system Plan: 2nd Qtr. FY 97	Advanced ion thruster system will be greater than 3 times lighter than chemical systems and enable trip time reductions of up to 3 times that of chemical systems.

Start low-cost booster Engine Turbopump Testing August 1997	The engines for a low-cost booster must prove extremely high reliability and dramatically reduced costs.

ACCOMPLISHMENTS AND PLANS

RLV

In July 1994, NASA initiated a series of cooperative agreements which will run through FY 1996. In structures and thermal protection systems, McDonnell Douglas Corporation and Rockwell International Corporation *are* undertaking multiple, small-scale demonstrations of reusable cryogenic tank systems, thermal protection systems. and composite primary structures. In advanced propulsion, several industry partners including Aerojet, Lockheed-Martin, McDonnell Douglas, Pratt & Whitney, Rocketdyne, and Rockwell *are* working on composite component development, integrated propulsion systems, tri-propellant main injectors. tri-propellant pre-burners, oxygen rich turbine drives, and modular chambers. Under these cooperative agreements, preliminary designs of components completed in FY 1994 moved to fabrication and testing in FY 1995; however, as a result of the new X-33 cooperative agreements between NASA, DoD and private industry signed in March 1995, some of the work being done under the FY 1994 agreements was redirected to better support the requirements of the overall RLV program.

NASA's DC-XA program is retrofitting DoD's DC-X flight 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. which began in FY 1995, will give an early indication of the viability of these new technologies. During FY 1995, the DC-X was disassembled and prepared for the advanced technology components to be integrated into the vehicle. All of the advanced technology components reached the Anal assembly, test, or checkout stage by the end of FY 1995. Initial flight test plans were completed and facility work was in progress at the test range at the end of the year.

With the signing of four new cooperative agreements in March 1995, work started on the concept design and definition of the X-33 large-scale demonstrator and on the X-34 small reusable booster. Three industry teams, led by Rockwell International, Lockheed-Martin and McDonnell Douglas-Boeing, signed X-33 agreements. The agreements have four main task areas: business planning, operations planning, system design and analysis. and supporting technology development. The supporting technology development tasks include work not addressed by the FY 1994 cooperative agreements but required for a successful X-33 demonstration program, including efforts in operations. structures. and propulsion, as well as aerosciences demonstrations (aerospike).

The RLV program underwent a NASA Non-Advocate Review (NAR) in June 1995.

In January 1996, work was stopped on the X-34. and the cooperative agreement between NASA and the team of Orbital Sciences Corp. and Rockwell International is in the process of being terminated by mutual agreement of all parties. Despite the termination

of the cooperative agreement, the X-34 will continue as a technology demonstrator. After redesign, it will be smaller in size than current configurations, which have a legacy of being sized for future commercial applications. The new X-34 will continue to meet all of NASA's top priority objectives as an early demonstrator of RLV technologies. Initial flight tests will begin in the summer of 1998. Operational experience will be gained through a repetitive series of flight tests in which the flight envelope is incrementally expanded. The vehicle will be built using advanced technologies in a modular design to permit the future infusion of newer technologies. such as advanced propulsion systems. new thermal protection systems and propellant tanks constructed of new materials and with new insulation. Flying these higher risk, new technologies on the relatively low-cost X-34 will allow the RLV program to gain key performance data on new systems which are too risky to fly on the much more expensive X-33.

The DC-XA is to complete integration and checkout of its new, upgraded components by the second quarter of FY 1996. DC-XA fight tests are scheduled for the third quarter of the year, in time to provide a comprehensive report of the performance of the technologies in support of the Phase 2 decision. If the DC-XA is successful, the technologies, as well as the operational lessons learned, will be applied to the X-34 and X-33 flight demonstrations.

The RLV program will complete demonstrations proving the maturity of technologies critical to meeting the criteria for the 1996 X-33 night demonstrator (Phase 2) decision. The preliminary data base on candidate RLV systems and subsystems options must be sufficiently complete to support the X-33 Phase 2 decision. Among the technologies to be demonstmted 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.

The X-33 industry teams are scheduled to submit their proposals for Phase 2 early in the third quarter of FY 1996. Selection of the winning X-33 concept(s) is to be based on the teams' proposals for sound business strategies/approaches and their technical approach to meeting the criteria for the decision at the end of the decade. In accordance with policy, approval to proceed with Phase 2 will be sought from the Administration prior to December 1996. If approval to proceed is granted in FY 1996, the industry team(s) will work to finalize X-33 flight demonstrator designs initiated under Phase 1, and will begin placing orders for X-33 long-lead items. In an effort to reduce risks in the X-33 program highlighted by the initial NAR, as well as in discussions with industry partners and in the FY 1996 Appropriations Conference report, NASA has rephased the funding for the X-33 Phase 2 effort. No additional resources were required in FY 1996, but $58 million has been moved forward from FY 1999 to FY 1997 to reduce risk to the X-33 schedule

The final RLV program NAR is scheduled for June 1996.

Specific activities for the X-33 in FY 1997 will be determined in part by which concept(s) are selected in 1996. A detailed schedule and program content description will be provided as part of the package sent to the Administration to gain approval to proceed with the program. Nevertheless, certain activities will have to be undertaken no matter which concept(s) proceed. The industry team(s) will have to work on Anal design and development of the X-33 demonstrator vehicle, including final component design, drawing release. tooling and facilities fabrication, and vehicle subsystem fabrication and test. This work must be completed in preparation for vehicle assembly in FY 1998 and first flight in FY 1999.

Advanced Space Transportation Technology

In April 1996, the Advanced Space Transportation Technology program will complete initial roadmaps and publish program plans. These Roadmaps and plans will prioritize the efforts to develop highly advanced technologies aimed at dramatically reducing both the cost to get to orbit and the cost/time required to transit in space. Initial efforts are expected to focus on technologies for low-cost, small boosters on Rocket-Based Combined Cycle (RBCC) engines and on high-energy in-space transportation. The RBCC is a highly advanced propulsion technology that combines the efficiencies of air-breathing systems in the atmosphere with the efficiencies of rockets in vacuum, thus offering substantial advantages over conventional rocket engines. In FY 1997. testing will start on reliable, low-cost turbopumps.

Transportation Technology Support

The SPIP Combustion Simulator was converted to a Hybrid test facility during FY 1995, and the SPIP Nozzle program was transitioned to examine Hybrid-suitable materials. The SPIP Bondline program was completed in early FY 1996. A Cooperative Agreement has been negotiated with the Hybrid Consortium, the industry consortium Articles of Collaboration have been signed, and initial testing of the small 24-inch hybrid motors is under way.

In 1995, In-Space Transportation funded solar electric flight systems design and ground test efforts, with a flight test planned before 2000 to demonstrate the readiness of electric propulsion technology as a primary spacecraft propulsion system. The Operations/Software activity expanded the application of automated scheduling from the Orbiter Processing Facility at KSC to the Vehicle Assembly Building and the launch pads. This budget line also funds the initial development of an electronic documentation system at the Johnson Space Center (JSC)'s Mission Control Center to eliminate millions of photocopy pages and streamline change processes. with expected savings of $3 million per year. In addition, the Operations/Software program will apply model-based diagnostics for ground controllers to detect faults in the Shuttle's propulsion system and develop techniques for on-board health management. The cooperative ELV activity completed fabrication of low-cost Al-Li components and finished a ground test rig for the Lockheed-Martin 14-foot diameter cryogenic tank tests. The team used the Lockheed-Martin 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 Testbed at MSFC. as well as trending techniques (feature extraction) algorithms developed by LeRC, were applied to the development of an automated propulsion diagnostic system for ground checkout of the Atlas Booster.

In 1996, the solar electric propulsion program will complete the first flight-ready solar electric thruster. The Operations/Software effort in 1996 will complete ongoing Shuttle-based demonstrations and begin focusing on supporting the automated systems requirements of the Reusable Launch Vehicle (RLV) 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 Lockheed-Martin, 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 Evolved Expendable Launch Vehicle program or the RLV program.

During FY 1997. the HPDP will complete most of the smaller component development testing and database generation, and will conduct extensive demonstration testing of large, 250K thrust motors. Several sounding rocket night demonstrations will be conducted. The In-Space Propulsion Technology program will continue to demonstrate the life and performance of the system on the ground and in space, worldng toward a launch planned for FY 1998 on a New Millennium satellite. Engineering Capability development will continue to fund utilization. maintenance. and productivity upgrades for the premiere national facilities at the Langley Research Center (LaRC) and the Ames Research Center (ARC) required to accomplish the goals of the Advanced Space Transportation programs.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACECRAFT AND REMOTE SENSING

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Spacecraft systems technology	67,000	51,800	39.900
Instrument/sensing technology	55.400	59,600	57,000
Autonomy and operations	13.400	14,300	23,000
Telerobotics	18,100	24,800	19,900
Communications	21,000	23,600	23,300
SBIR funding allocation	--	--	-12,100
To	174.900	174.100	151.000

PROGRAM GOALS

The Spacecraft Systems program has the primary goal of providing innovative technologies to enable ambitious future space missions and to support development of the required space technology base in the U.S. space industry through focused, joint space technology efforts.

The future of NASA space science missions will largely be determined by the ability of NASA to reduce mission costs without reducing performance and payoffs. The Spacecraft Systems program will address this challenge by working to develop technology products for future planetary, astrophysics, astronomy, Earth observing, and human exploration spacecraft systems. These products will dramatically reduce costs and increase performance to enable new and more flexible missions.

STRATEGY FOR ACHIEVING GOALS

The program plans to accomplish its tasks by focusing technology development on key objectives: (1) reduce the mass and increase the efficiency of spacecraft subsystems and systems to enable use of smaller launch vehicles; (2) increase on-board and ground system autonomy to reduce overall mission operations cost; and (3) exploit micro-fabrication technology to develop miniaturized components and instruments with equal or better performance than current components and Instruments.

Overall Spacecraft Systems program goals will be achieved through a balance of near-term and far-term activities. Far-term basic research (~5-10 year horizon) will identify and exploit major new scientific and technical discoveries to enable new missions, and near-term (< 5 year) development will be targeted to specific user needs for currently planned missions. In general, the far-term efforts will comprise about 25% of the program, carrying new ideas through laboratory demonstrations. The more near-term focused program will comprise about 75% of the program, indicative of the high cost of systems-level, integrated demonstrations.

The Spacecraft Systems program will utilize a comprehensive technology development strategy combining ground-based and space-based efforts. As required, selected technologies will be validated in space through flight experiments on a variety of platforms, including: technology demonstration spacecraft, laboratories in orbit such as Mir or the International Space Station: spacecraft with primary science missions which have space available for experimental payloads: or dedicated. free-flying, experiment platforms. The Spacecraft Systems program is closely integrated with the Advanced Smallsat Technology program, and with the New Millennium Program for Space Science and Mission to Planet Earth. in order to allow the fastest possible insertion of new technologies into demonstration spacecraft. Nevertheless, space demonstrations will be used only when testing in a ground-based laboratory is not appropriate or is not achievable due to the inability to accurately simulate the on-orbit environment.

To assure maximum efficiency of resource utilization. the Spacecraft Systems program has been restructured around cross-cutting technology areas that address all current and future missions. This new structure will enable identification of technologies that can best meet the requirements of NASA missions across all program areas (space science, Earth science, commercial communications, etc.) rather than focusing on individual mission requirements. The key cross-cutting areas are spacecraft systems technology. instrument and sensing technology (including commercial remote sensing), autonomy and operations. telerobotics and communications.

The Spacecraft Systems Technology program funds developments in power and propulsion, materials and structures, electronics and avionics, and systems analysis. The program will include a special emphasis on integrated design techniques and fabrication methods to produce modular spacecraft incorporating microsystems and micro-instruments. The program will demonstrate advanced thermal systems as well as lightweight space power concepts and systems including batteries, and high-efficiency, low-weight photovoltaic arrays. The program will also fund development of on-board electric and high-impulse chemical propulsion systems: advanced, high-performance, low-power data management systems; improved environmental models; and compact, lightweight deployable structures.

The Instrument/Sensing Technology program is focused on the critical need to reduce the size and complexity of science payloads in order to reduce the cost of future missions, particularly for Earth science. The program will also emphasize development of instruments with new scientific capabilities. such as detectors and measurement systems to allow scientific measurements in new regions of the electromagnetic spectrum, and interferometer technology for unprecedented resolution of small and distant objects. Interferometry could provide direct evidence of Earth-like planets around sun-like stars. The Instrument/Sensing program will also continue to fund cooperative efforts with industrial partners aimed at enabling development of a viable Commercial Remote Sensing industry. The cooperative effort will work to apply space-based data and instrument technology in the development of usable, customer-defined information products. Industry will make significant co-investments. funding the Commercial Remote Sensing Program (CRSP) at about an equal level with NASA.

Autonomy and Operations Technology will emphasize the insertion of new approaches to reduce the Me-cycle cost of science missions. The program will emphasize on-board autonomy as well as highly intelligent ground systems to allow hands-off spacecraft operations and automated science data analysis and archiving.

In the Telerobotics program, the Mars Pathfinder mission will demonstrate operation of the first U.S. telerobotically operated rover on another planetary body (and the first ever on Mars). Work will also focus on enabling lower cost planetary rovers with greater capability. Telerobotics technology will also be pursued to reduce the cost of on-orbit activities such as assembly and servicing of space stations, as well as to allow automated tending of science payloads.

In the Communications program, the strategy is to develop improved space communications technology to meet NASA science and exploration mission requirements for the 1990's and beyond, as well as to support commercial needs. The program will develop advanced technology for high data rate transmission (multi-gigabit per second) for deep space and near-Earth communications systems. It will also continue efforts to stimulate the competitiveness of the U.S. satellite communications industry by developing standards, protocols. and interoperability among space and terrestrial networks. Experiments with the Advanced Communications Technology Satellite (ACTS) will be co-funded with industry and continued through FY 1998, when the spacecraft is expected to run out of propellant.

MEASURES OF PERFORMANCE

Complete three preliminary PNGV definitions vehicle Plan: September 1995 Accomplished 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 Plan: 1st Qtr., FY 95 Accomplished: 1st Qtr., FY 95	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 Plan: 4th Qtr., FY 95 Accomplished: 4th Qtr.. FY 95	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 Plan: 4th Qtr., FY 95 Accomplished 4th Qtr., FY 95	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	These databases will reduce costs and increase the accuracy of spacecraft design margins.

Plan:	4th Qtr., FY 95
Accomplished:	4th Qtr., FY 95

FY 1996

ACTS Broad-band aeronautical terminal experiments begin Plan: October 1995 Accomplished: December 1995	A unique capability in live video and data transmission for commercial aviation application will be demonstrated. Began in December due to Agency funding decisions.
Complete the development of a high-efficiency (50%) Traveling Wave tube (TWT) for Ku-Band (12-14 gigahertz (Ghz)) for commercial satellite applications Plan: February 1996 Accomplished 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 Plan: 2nd Qtr. FY 96 Current: 2nd Qtr. FY 96	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 (ISDN) modem Plan: July 1996 Current: 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 Plan: 4th Qtr. FY 1996 Current: 4th Qtr. 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 Plan: 4th Qtr. FY 96 current: 4th Qtr. FY 96	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 Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	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 Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	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 Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	These guidelines will provide the first common basis for design and analysis of safely-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 Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	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 Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	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" Plan: 4th Qtr. FY 96 Current: 4th Qtr FY 96	Multiple. very small (silverdollar 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 Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	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 Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	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 Plan: September 1996 Current: September 1996	This work will support the satellite industry in developing less expensive satellite antennas.

FY 1997

Complete cryogenic optical beryllium mirror technology Plan: 1st Qtr. FY 97	This technology provides lightweight., high-performance optics to reduce the cost of missions, such as SIRTF, requiring cryogenic infrared telescopes.

Operate Mars Pathfinder micro-rover on surface of Mars Plan: 3rd Qtr. FY 97	As the first micro-rover to be flown, this system will pave the way for future planetary exploration missions utilizing small rover systems.
Demonstrate optimized infrared detector array for astronomy and planet detection Plan: 3rd Qtr. FY 97	The array will be a 256x256-element, impurity-band conduction (IBC), arsenic-doped-silicon (Si:As) device. This technology supports missions that require high-performance, cryogenically-cooled detector arrays at wavelengths near 40 microns.
Validate ultraviolet laser crystals for use in accurate remote atmospheric observation Plan: 4th Qtr. FY 97	For both aircraft and space-based missions, NASA has a need for stable, high-performance tunable lasers to measure atmospheric constituents in order to increase our understanding of ozone depletion, global warming, and other climate-related topics. This program will demonstrate a differential absorption LIDAR (DIAL) for observing water vapor, ozone. cloud top heights, and aerosols.
Flight demonstrate a micro-gyroscope with control electronics. Plan 4th Qtr. FY 97	A microgyroscope with 10 degrees per hour drift rate will be demonstrated on a DC-8 flight. This technology supports control and guidance systems for micro-spacecraft, landers, and rovers.
Develop small advanced monopropellant rocket Plan: 4th Qtr. FY 97	A nontoxic monopropellant chemical system with 25% greater performance than current systems will be developed to support small satellite missions.
Demonstrate 25% efficient production-quality solar cells Plan: 4th Qtr. 97	Efficiency of these new multi-band gap. large-format, solar cells will be –40% greater than the best available cells today.
Demonstrate advanced Ni-Hydrogen battery Plan: 4th Qtr. 1997	This battery will deliver 100 watts per kilogram and have a 10-year life in LEO. approximately twice the performance of current batteries.
Complete ACTS hybrid high-data rate mesh network. Plan: 4th Qtr. FY 97	Hybrid networking among space and terrestrial fiber communications networks in the NII will be demonstrated.

Reduce size and weight of a communication system by 2-3 times. Plan: 4th Qtr. FY 97	Reductions will be achieved by integrating an advanced 20-Ghz phased-array antenna system space-based in a communications network
Complete development of a high-efficiency modem for satellite applications Plan: 3rd Qtr. FY 97	The new asynchronous transfer mode device will transmit 155 million bits per second in hybrid space/terrestrial systems to provide efncient digital communications systems for the National Information Infrastructure (NII)/Broad Band Global Information Infrastructure (GII).
Complete aeronautical and maritime mobile experiments using ACTS satellite and mobile communications terminals Plan: 4th Qtr. FY 97	Advanced Communications Technology Satellite (ACTS), working with NASA-developed mobile terminals, allows demonstration of advanced mobile communications technologies in broad-band aeronautical and wideband (3.0 Mbps) maritime communications systems. NASA will transfer technology products to the mobile communications industry for commercial aviation and maritime applications.

ACCOMPLISHMENTS AND PLANS

Spacecraft Systems Technology

In FY 1995. the space power program within the Spacecraft Systems Technology line item continued to develop component technology and systems concepts for *high* efficiency, compact power systems. The program has completed the 2-kW Solar Dynamic Ground Test Demonstration, which was the first end-to-end demonstration of a complete system designed for space operations. The program was completed 6-months early and about $2 million below budget. The system performed as designed under conditions simulating the thermal and vacuum environment of low Earth orbit. In another experiment. advanced photovoltaic concentrator cells were demonstrated on-orbit for over 8-months (to date) in a high radiation environment. Degradation from radiation damage was negligible, demonstrating the ability of the design to protect a high-performance army that would otherwise decay rapidly in this environment. *An* advanced lithium battery cell was also developed with 4 times the capacity of any previous cell and 3 times the specific energy of the best state-of-the-art nickel-cadmium battery. The on-board propulsion program continued to develop advanced spacecraft propulsion systems for government and commercial applications. In FY 1995, the second generation high performance arcjet was accepted for a commercial application (Lockheed Martin A2100 series spacecraft), and rocket front end cooling technology developed under a joint LeRC/TRW program was selected for use in the AXAF mission. The space data systems program demonstrated a 3-D computer on a multi-chip module using a radiation-hardened 32-bit processor chip set.

In FY 1996, the focus of the Spacecraft Systems Technology program element will continue to be on smaller, more efficient, lower-cost sub-systems and systems. The on-board propulsion program will demonstrate a small, pulsed-plasma, electric propulsion

system for efficient orbital position and trajectory control of small spacecraft, and will conduct a performance demonstration of a non-toxic monopropellent chemical system. Advanced photovoltaic cells with 24% efficiency will be demonstrated and a program exploring dynamic energy storage (potentially 2-3 times more efficient than chemical storage on an overall spacecraft system basis) will be initiated. Studies are also planned on advanced energy conversion methods to reduce the amount of radioisotope needed for deep space missions by up to 5 times. Low temperature electronic power system components will be characterized at very low temperatures (-10 degrees K) for operation in very harsh deep space environments. In space data systems, a 3-D stacked. multi-chip, 1 Gbit, solid state memory module will be built to replace data recorders. It will be 10 times lighter and smaller than current systems.

In FY 1997, the spacecraft systems technology program element will continue with the objectives of increasing the performance of spacecraft systems by at least 2 times. while decreasing mass and volume by 2-3 times and cutting costs about 2-3 times over the best available current systems. The on-board propulsion program will continue development of high-efficiency electric propulsion technology for orbital insertion and maintenance. Electric propulsion technology can reduce trip times for deep space missions by 3 times. The space power program will demonstrate battery technology to double the Me of current batteries in LEO and photovoltaic technology to increase efficiency by 40%. Combined with lightweight array technology, this effort will lead to systems capable of about 300 W/kg at about one-third the cost of current systems. A breadboard demonstration of an advanced low vibration, low power refrigerator/freezer for use on the International Space Station will be demonstrated. The flight data systems program will demonstrate a complete 3-D stacked, multi-module avionics architecture that is 10 times smaller than current spacecraft avionics systems. In addition. guidance/navigation algorithms will be validated for autonomous cruise and maneuver control.

Instrument/Sensing Technology

In FY 1995. the sensors and instrument program demonstrated large-format infrared arrays with improved producibility for both Earth science and astrophysics mission applications. This included demonstration of a 256x256 element quantum well infrared photodetector (QWIP) array. The QWIP array has the potential for reducing the mass, power requirements, and complexity of Earth observing instruments in the 15 to 20 micron range. For sensitive astrophysics observations, demonstration in FY 1994 of a 600 GHz submillimeter mixer ahead of schedule enabled the demonstration of a 700 GHz mixer in FY 1995. For Earth science applications, several local oscillator approaches for the measurement of the hydroxyl radical at 2.5 terahertz were developed in FY 1995. Progress in the development of micro-electro-mechanical systems (MEMS) components in FY 1995 led to flight demonstration of a micro-hygrometer that out-perfoms current, large instruments. Hughes Danbury Optical Systems (HDOS) delivered the primary mirror for the infrared telescope technology testbed to the JPL cryogenic optical test facility. In FY 1996, HDOS will complete delivery of the testbed and JPL will conduct cryogenic optical and random vibration testing.

The sensors and instruments program supported 8 new Earth Observing Commercial Applications program (EOCAP) cooperative projects in FY 1995. covering a portfolio of products and services that range from sensor development and desktop mapping software design to rangeland management and TV weather forecasting. These projects will be completed in FY 1997. In addition, eight EOCAP projects begun in prior years were completed in FY 1995. including agricultural production management, marine vessel surveillance and gas pipeline monitoring.

In FY 1996, the 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. These technologies include development of uncooled infrared as well as large-format. visible. ultraviolet, x-ray, and high-energy detector arrays. For sensitive astrophysics observations in the submillimeter region of the electromagnetic spectrum, an 800 GHz submillimeter mixer will be demonstrated in FY 1996. For Earth science submillimeter applications, development in FY 1996 of the most promising local oscillator approach for the measurement of the hydroxyl radical at 2.5 THz will be combined with the hot electron bolometer mixer concept to demonstrate a new instrument approach.

Micro-electro-mechanical systems (MEMS) technology will be utilized in several FY 1996 efforts: a prototype package for a Mars/Earth upper atmosphere micro-weather station will be completed: a high-performance. integrated 'camera-on-a-chip" active pixel sensor for miniature imaging systems will be demonstrated and the components for an integrated free-flying magnetometer 'spacecraft-on-a-chip" will be tested.

Also in FY 1996. a technology testbed 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) will be completed at the JPL cryogenic optical test facility. NASA will. in addition, increase emphasis on developing 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.

Space commercialization will be promoted in FY 1996 by continued support for the CRSP partnerships with industry. The Earth Observing Commercial Applications Program (EOCAP) will solicit and award cooperative agreements with industry focused on technologies to apply and utilize hyperspectral imaging data. This activity will build on the opportunities presented by the Small Spacecraft Technology Initiative which will launch two spacecraft in FY 1996 with hyperspectral and high-resolution instruments.

In FY 1997. Instrument/Sensing technology will continue to focus on expanded spectrum performance and micro-miniaturization for both Earth and space science. Program emphasis will be increased in the areas of space interferometry to support ultrahigh resolution astrometry missions and extra-solar planetaxy exploration programs. In FY 1997, the technology testbed for an advanced infrared telescope will validate new technology for use by future infrared astronomy and planet detection missions. This technology can reduce the size and cost of such a telescope by at least half while increasing performance. The development of sensor and instrument technology for compact, low-cost space radar systems will continue in FY 1997 with the goal of enabling a low-cost flight demonstration of lightweight synthetic aperture radar technology. Advanced space laser technology will be developed to enable a much smaller, lower power future LIDAR system for atmospheric observations. The program will also support deployable concepts for highly efficient packaging of solar arrays, optics, etc. to enable spacecraft with large collecting surfaces to be launched in smaller launch vehicles. A very high frequency (2.5 Thz) submillimeter receiver will be demonstrated to measure components of upper atmosphere ozone chemistry that currently cannot be monitored from space. In addition, EOCAP will solicit and award a new series of projects focused on environmental monitoring.

Autonomy and Operations

In FY 1995, JPL has developed an artificial intelligence application which searches massive image databases, and finds (discovers) phenomena of interest using an adaptive pattern recognition system. This tool, called JARTOOL, discovered ten quasars this year in a small fraction of the time and cost it would taken humans analyzing the data. JPL has also developed a tool to automate the planning for generating image processing requests. This tool. called the Multimission Vicar Planner (MVP), has been selected for use by the Galileo project office. MVP reduces the time taken by an expert to develop an image processing plan from 4 hours to 15 minutes. Ames Research Center (ARC) has developed software which plans, schedules. controls and monitors telescopes. This new technology is now in use on four telescopes located at Fairborn Observatory. All U.S. manufacturers of automated telescopes are incorporating this technology. ARC has also developed a super-resolution algorithm which was applied to a sequence of 21 images of Gaspra taken by Galileo. The resulting images show craters and other features far smaller than the resolution of any of the individual input images.

In FY 1996. the operations program continues to focus on reducing overall mission costs by improving spacecraft and ground systems. The program encompasses artificial intelligence applications to reduce direct dependence on human operators and on the people retrieving and analyzing data. This technology will improve the return of science data and the extraction of critical information on spacecraft health from returned operating performance data A software architecture for highly autonomous spacecraft will be demonstrated. The activity includes onboard command sequence development and validation for autonomous maneuvers, for science instrument control and for onboard data reduction prior to downlinking. By processing the data on board the spacecraft, the costs of data management and analysis can be reduced by a factor of at least ten.

In FY 1997, the Autonomy and Operations program will demonstrate, using an operational spacecraft, onboard autonomous control of delta-V maneuvers, pointing and orbit determination, as well as fault detection and recovery. Also, technology development will continue to enhance capabilities for autonomous spacecraft health management. This work consists of "model-based reasoning" techniques which will enable spacecraft to detect, diagnose and work around anomalies which the spacecraft was not programmed to handle. This technology will enable full autonomy while ensuring robust performance in response to unplanned anomalies.

Telerobotics

During FY 1995, the space telerobotics program completed the initial development of the neutral bouyancy engineering vehicle for the Ranger telerobotic technology. and began testing of the system in the Neutral Bouyancy Research Facility at the University of Maryland. A Mars-like planetary rover demonstrated several 100-meter, autonomous traverses over simulated Mars terrain. A lunar rover prototype was developed, and the year's activities culminated in a 10-kilometer autonomous traverse across natural terrain, with human control limited to designation of the vehicle heading and end goal. The program also completed development and integration of the "Tesselator", a robotic system for the inspection and processing of the thermal protection tiles on the Space Shuttle orbiter, and delivered the system to the Kennedy Space Center. In addition, the program completed development of autonomous surface inspection technology for the robotic examination of exposed surfaces on space structures. The inspection technology was delivered to the Space Station program at the Johnson Space Center. The program is continuing to develop, in

conjunction with industrial partners. the Robotically-Assisted Microsurgery System, which is implementing a robotic system for precise manipulation of surgical tools for ocular surgery. These manipulations are constrained to a 1-cubic-inchwork envelope, and must achieve a level of precision and repeatability on the order of 10 microns.

In FY 1996, the Telerobotics program will emphasize applications to Earth orbiting platforms and planetary surface operations. The program will initiate development of the AERCam system. a robotic "flying eye" for servicing and inspection of external Space Station payloads. This system, which will work in conjunction with EVA astronauts during Space Station operations, is planned for first flight in FY 1998 and will demonstrate the use of advanced robotics technology to reduce EVA astronaut workloads. Among other telerobotics tasks. the Mars Pathfinder rover flight unit will be integrated into the spacecraft in preparation for launch at the end of FY 1996.

In FY 1997, NASA will complete operations of a 10-kilogram (kg) microrover on the Mars Pathfinder mission. The rover will be used to provide images of the lander to assess its condition on the planet's surface: it will 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. The program will also continue development of the next generation of planetary surface micro-rovers. targeting a 50% reduction in rover mass and volume and development of technologies for planetary and small body sample collection, preservation and autonomous analysis by FY 1998.

Communications

In FY 1995. the space communications program accomplished an extensive number of unique ACTS experiments performed in the areas of telemedicine, tele-education and demonstration of high data rate transmission via satellite. The program completed the development of a high-efficiency (50%) traveling wave tube (TWT) for Ku-band (12-14 GHz) for commercial satellite applications. Addittonally, the technology program focused the research elements, with inputs from industry. on technology needs to support the role of satellites in the National Information Infrastructure (NII)/Global Information Infrastructure (GII). In particular, the program is looking at the technology needed to develop standards, protocols. and interoperability among terrestrial and satellite networks. The program also demonstrated a transmission rate of 622 megabits/sec with the ACTS spacecraft.

In FY 1996, using high data rate terminals activated in 1995. we will demonstrate satellite connectivity among super computers at a data rate of 622 Mbps. This effort will enable fast distribution of scientific data among research laboratories in the U.S. This will be the first time that such widely distributed research centers were connected through satellites.

In FY 1997. NASA and industry will work together to demonstrate wide-band communications integrating space and terrestrial systems. Standards, protocols and Interoperability for a world-wide, seamless multimedia network will be developed and demonstrated. The wide-band-capable new terminals and ACTS will support the first real-time. live transmissions of telescience, tele-education, and remote sensing Information. Technology demonstrations will be completed that combine real-time. aeronautical and maritime, high-data-rate communications enabling communications at a rate about 10X greater than is possible today. The advanced antenna system will use a System-Level Integrated Circuit (SLIC)/Monolithic Microwave Integrated Circuit (MMIC) 4-element phased-array antenna system in a communications network. The effort is a partnership with the satellite

industry to reduce the cost of satellite phased-array antennas. A new asynchronous transfer mode device will transmit 155 million bits per second in hybrid space/terrestrial systems to provide efficient digital communications systems for the National Information Infrastructure (NII)/Broad Band Global.

BASIS OF FY 1997 FUNDING REQUIREMENT

ADVANCED SMALLSAT TECHNOLOGY

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Small spacecraft technology initiative (SSTI)	61,900	39,100	30,000
To.....	61,900	39,100	30,000

PROGRAM GOALS

The goals of the Small Spacecraft Technology Initiative (SSTI) *are:* 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: to promote actively commercial technology applications; and to initiate new technology demonstrations that emphasize advancements in components, instrument technology and operations.

STRATEGY FOR ACHIEVING GOALS

The SSTI program is closely aligned with New Millennium program In the Office of Mission to Planet Earth. *All* future SSTI missions wlll be selectedjointly by Space Access and Technology and Mission to Planet Earth, with the aim of linking the technology demonstrations directly to the needs of the users in the science community. This arrangement wlll allow a higher return for our technology investments, and allow new technologies to be Aelded more quickly.

NASA will continue to use highly integrated product development (IPD) teams to bring together industry. small business. academia, and government technologists. SSTI will continue to demonstrate "time-to-orbit" in less than two years. The program will also develop new ways of conducting business, unconstrained by traditional government specifications and excessive oversight.

The advancement of small spacecraft technology also provides new opportunities for U.S. industry in commercial spacecraft, in technology transfer for development of other commercial products, and in the development of new markets. Currently, by reducing cost and allowing more frequent space missions, SSTI offers improved market opportunities for U.S. companies in remote sensing and communications. In the future, small commercial spacecraft might supply scientific data needed for studying and monitoring the global environment. SSTI also fosters a focused effort on insertion of technology into new commercial products and creation of new business opportunities for U.S. companies in such applications as transportation, medicine, manufacturing, and consumer products.

MEASURES OF PERFORMANCE

Mission Operations Plan/ Design Reference Mission Plan: 1st Qtr. FY 95 Accomplished 1st Qtr. FY 95	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. The policy was initiated on schedule, and is being updated quarterly.
Detail Design Concurrence Plan: 1st Qtr. FY 95 Accomplished: 1st Qtr. FY 95	Early concurrence of the detailed designs is crltical 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 Plan: 3rd Qtr. FY 95 Current: 4th Qtr. FY 96	This milestone is necessary to fulfill the commitment to the spacecraft industry that NASA would share! the spacecraft design processes being implemented. It has been postponed until the 4th quarter of FY 1996 to allow launch data to be incorporated.
Instrument Acceptance/Delivery Plan: 1st Qtr. FY 96 Accomplished:	Instrument acceptance and delivery at this time is critical to meeting the flight schedule.
Concurrent Integration Plan: 2nd Qtr. FY 96 Accomplished:	Complete concurrent integration to meet the flight schedule. A *small* schedule contingency currently exists to accommodate any last-minute schedule adjustments.
Spacecrafts to Launch Site and Launch Site Operations Plan: 3rd Qtr. FY96 Current: 3rd Qtr. FY 96	Ship spacecraft at this time to allow sufficient time to mate the spacecraft with the launch vehicle and prepare for the launch.
Launch both Spacecraft Plan: Clark June 1996 Plan: Lewis July 1996 Current Clark: Under review Current Lewis: Under review	NASA and industry to meet the commitment for a 24-month period between contract initiation and launch of the spacecraft. This provides the primary metric for determining the amount of any award fee. Planned launch dates are currently under review due to the failure of the initial launch of the Lockheed Launch Vehicle (LLV-1). The requirement for an additional LLV-1 test launch prior to launch of the Smallsats would delay their flights.
Begin On-Orbit Operations Plan: 4th Qtr. FY 96 Current: 4th Qtr. FY 96	Initial on-orbit operations must begin at this time to meet the terms of the contract and meet the need for timely Earth observation data.

Clark Operations Complete Plan: 4th Qtr. FY 97	Technologies will be proven for spacecraft design with a life of one year.
Next Series Spacecraft Plan: 1st Qtr. FY 97	Initiate new technology demonstrations that emphasize advancements in components, instrument technology and operations.

ACCOMPLISHMENTS AND PLANS

Spacecraft design and mission operations plans were completed in the first quarter of fiscal year 1995. As a result, the data collection policy, data archiving system, and spacecraft tasking policy were completed on schedule. 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 Redondo Beach, CA office. NASA is managing both projects from NASA Headquarters. In FY 1995, the designs of both spacecraft and the integration of all systems, technologies. and instruments on the two spacecraft was completed.

Lewis and Clark will be completely tested, delivered. and integrated with the launch vehicles at the launch site in FY 1996. Launches *are* planned for June and July 1996 for Clark and Lewis, respectively, but are under review due to the failure of the initial launch of the Lockheed Launch Vehicle (LLV). The requirement for an additional LLV-1 test launch prior to launch of the Smallsats would delay their flights. Initial on-orbit checkout of the spacecraft will be completed during the first 3 months after launch. and experiments will be initiated. Lewis will carry 25 new technologies and Clark will carry 36, including composite structures, advanced avionics and high-efficiency power systems. Lewis will also have three advanced sensors to meet the needs of the commercial remote sensing and Earth science communities: a 384-band hyperspectral imager; a Linear Etalon *Array* to scan the Earth and its horizons; and an instrument to measure the W cosmic background. Clark will have a high-resolution imager capable of 15-meter multi-spectral and 3-meter panchromatic measurements: an instrument to measure pollution in the troposphere: and an x-ray spectrometer to capture bursts from solar flares.

The process for selection of next-generation technologies will also occur in FY 1996. The Office of Space Access and Technology and the Office of Mission to Planet Earth *are* coordinating efforts to select the most promising advanced technologies that will reduce the cost of future Earth observing missions.

On-orbit operations of Clark spacecraft will be completed in late FY 1997 with continued on-orbit operations of the Lewis spacecraft into FY 1998. Imaging data will be available to users throughout the year. Several student groups nation wide (including schools with high minority populations) *are* among the users of Lewis *imaging* data.

Funding in FY 1997 will be focused mainly on the next generation of small spacecraft with an emphasis on major advances in imaging and measurement capability. Potential candidates that have been analyzed recently include an advanced low-cost, multi-spectral imager, a lightweight, low-cost synthetic aperature radar (SAR), a demonstration of formation *flying* and a lightweight, low-cost light detection and *ranging* (LIDAR) system.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACE PROCESSING

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Space product development	18.300	17,700	13,000
Space station utilization	15.000	36,300	31.600
SBIR funding allocation	--	--	-2.800
To	33.300	54.000	41.800

PROGRAM GOALS

The Space Processing program has two elements: Space Product Development and Space Station Utilization. The Space Product Development program goal is to facilitate the use of space for commercial products and services. These products and services *can* be produced in space, can be derived from knowledge acquired in space, or can be the result of new approaches to ground-based commercial activities using insights gained from space flight. Consistent with this goal, the Space Product Development program seeks 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 program also seeks to provide the opportunity for students to engage with industry in space program activities, in order to help provide individuals with new insights and qualifications for exploiting the benefits of space.

The Space Station Utilization program goal is to support the development and operation of space processing and technology research payloads using space stations as long-duration orbital facilities. These payloads will allow development of new products for both aerospace and non-aerospace applications, for both commercial and government use. An additional goal for the Phase I Space Station experiments activity is to reduce risk for follow-on phase II/III Station activities.

STRATEGY FOR ACHIEVING GOALS

The Space Product Development program to increase the number of products and services that utilize the attributes of space is conducted in partnership with industry, universities, state governments and other Federal agencies. To reach new partnership agreements, the program uses Centers for the Commercial Development of Space (CCDS), specific project centers, such as the Environmental Research Institute of Michigan. and several NASA Field Centers (Goddard Space Flight Center. Langley Research Center, 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 Product Development program provides access to experiment facilities and offers frequent access to space to meet commercial requirements by utilizing the Shuttle mid-deck, SPACEHAB. Wake Shield facilities and, when available, Space Station. Such access is prohibitively expensive for most single

corporations or small business. and this barrier to entry has greatly retarded the commercial development of high-risk space-linked products. Through the cost-sharing partnerships between NASA, the universities and industry offeredby the Space Product Development program, private enterprises of all sizes are able to afford the research most important to the development of space-linked commercial products.

The Space Station Utilization program is organized into three phases. In Phase I. experiments will be selected and flown on the Shuttle-Mir nights to reduce risk and validate technology for Phase II/III International Space Station systems and payloads, as well as to conduct space product development research activities. Phase I will include seven 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.

The Phase II/III Space Station Utilization program involves two main thrusts. The first is to select and develop space product development 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. 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 users. 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 the preparation of payloads for launch.

MEASURES OF PERFORMANCE

Alpha Interferon Experiment STS-63 and STS-70 Plan 2/95 and 6/95 Accomplished 2/95 and 6/95	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.
SPACEHAB-03 commercial experiments Plan: February 1995 Accomplished: 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 Plan: February 1995 Accomplished 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.

Flight experiment to develop new contact lens material on STS-63 Plan: February 1995 Accomplished: February 1995	Langley Research Center and industry partner Paragon Vision Sciences Corporation are worklng to develop a better contact lens material with greater stability, increased oxygen flow and greater retention of liquid.
Metal Sintering Experiment on STS 63 Plan: February 1995 Accomplished 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 plan: July 1995 Accomplished: 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 epltaxial 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 Plan: September 1995 Accomplished September 1995	Marshall Space Flight Center and Worcester Polytech Institute grew enhanced zeolite crystals durlng this flight. These crystals will have application In the petrochemical, electronics, oil and water treatment industries.
OAST Flyer mission on STS-72 Plan: September 1995 Accomplished 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.

FY 1996

Micro-encapsulation of Pancreatic Islets for Diabetes Large animal trials begin April 1995: Small animal trials end. Plan: October 1995 Accomplished 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.

Develop first Factor D compound for clinical trials Plan December 1995 Accomplished: 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 Plan: December 1995. Accomplished 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 Plan: January 1996 Accomplished: 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.
Launch Voucher Demonstration program Plan: 2nd Qtr. FY 96 Current: 2nd Qtr. FY 96	Congressionally mandated Launch Voucher Demonstration program (Section 504. Public Law 102-588). Interim report in early FY 1997.
Ship Energy Module (Solar Dynamic) Plan: February 1996 Current: Terminated	Ship hardware to Russia for integration. ISSA risk mitigation experiment sponsored jointly by the ISSUE program. OSAT, and Russia The energy module effort has been terminated due to fiscal constraints.
Flight of Commercial Generic Bioprocessing Apparatus with industrial samples on STS-76 Plan: March 1996 Current: 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-Mlr Mission 3 (STS-76) Plan: March 1996 Current: March 1996	This metal sintering experiment will use the Russian Optizon furnace to investigate the defect-trapping behavior of sintered metals in micro-gravity.

Deliver initial EXPRESS Rack Plan: April 1996 Current: April 1996	This rack will be flown on the Shuttle to validate the fast and easy payload integration planned for the Space Station.
Fly new contact lens material on STS-77/ Spacehab 4 Plan: April 1996 Current: April1996	Langley Research Center and industry partner Paragon Vision Sciences Corp. will develop enhanced rigidized contact lenses through growth of polymer material in microgravity.
Fly Immune-3 on STS-77/ Spacehab 4 Plan: April 1996 Current: April1996	Develop drug counter-measures to support long-term spaceflight as well as drug therapies to strengthen immune systems of patients.
Complete Phase I of Protein crystals on orbit. Plan: April 1996 Current: April 1996	Accelerate the acquisition of structural data on biomolecules through x-ray diffraction of Crystallization Facility for Space Station.
Fly Commercial Material Dispersion Apparatus (CMIX)-5 Plan: spring 1996 Current: April 1996	Flight opportunities will provide an extensive fluid sample capability (hundreds of samples) to researchers. targeted towards cell research for cancer treatment on STS-77
Fly Shuttle-Mir Mission 4 (STS-79) Plan: August 1996 Current: August 1996	Take two payloads to orbit for operations during Shuttle-Mir Increment 3 (Materials in Devices Superconductors Commercial Generic Bioprocessing Apparatus): return samples from Liquid Phase Sintering activities on MIR increment 2.
Commercial Protein Crystal Growth experiment on Shuttle-Mlr Mission 4 (STS-79) Plan: August 1996 Current: August 1996	This experiment will further develop capabilities to grow unique protein crystals in space.

Fly Extreme Temperature Translation Furnace SPACEHAB-5, STS-79 Plan: August 1996 Current: August 1996	Commercial Research will be conducted in high-temperature sintering and other high-temperature furnace applications.

FY 1997

Fly Wake Shield Facility on STS 80 Plan: November 1996	The Space Vacuum Epitaxy Center (University of Houston) and industrial sponsors are using this Wake Shield reflight for epitaxial growth of high-quality. thin-film semi-conductors in "ultra vacuum." Applications include advanced, high-speed optical and high-frequency devices.
Start X-Ray Diffraction Facility Plan: 1st Qtr. FY 97	The Center for Macromolecular Crystallography at the University of Alabama-Birmingham and its industrial partners will initiate Phase II of the X-Ray Diffraction Facility to be used on the ISSA for determining the structure of protein crystals grown in-situ
Initiate Design and Preliminary Development of Zeolite Crystal Growth Facility Plan: 2nd Qtr. FY 97	The structure of zeolite crystals. when grown In microgravity. can point the way to improved catalytic ability for zeolites used in the petroleum refining industry. The Center of Excellence for the study of zeolites and their industrial partners will define experiments to be performed using this facility.
Flight of Plant Biotechnology Chamber Experiment Plan: 3rd Qtr. FY 97	The Plant Biotechnology Chamber. based on the well proven Astroclture chamber technology, will be flown containing plants of interest to the agricultural and pharmaceutical industry.
Development of Experiments Placed on ISSA during Phase 11 Plan: FY 1997	Six flights to the ISSA have been designated Utilization Flights during phase II. Experiments to occupy approximately 40% of the U.S. Laboratory volume will be placed on the Space Station.
Fly Mir Mission 6 Plan: September 1997	Return Commercial Bioprocessing Apparatus and Liquid Phase Sintering Samples. Fly Maser clock on Mir to determine its long-term frequency stability for radio-astronomy, relativity and gravitational research.

ACCOMPLISHMENTS AND PLANS

The Space Processing program has made significant progress in developing commercial uses of space. The program has attracted over 150 industrial affiliates who committed cash and in-kind resources in excess of $30 million in FY 1994, compared to NASA's investment of about $20 million in that year. Industry investment is expected to increase annually by 10% in FYs 1996 and 1997. The program has already resulted in over 40 patents (a total which is expected to increase by about 10 per year) and over 25 spin-off companies (increasing at 3-4 per year).

In FY 1995. the Space Product Development program manifested payloads on five of six shuttle flights. These payloads included 26 flight experiments using Shuttle mid-deck lockers, SPACEHAB, and the second flight of the Wake Shield Facility. These experiments provided information for technology developments in industrlal areas, such as, pharmaceuticals. medical devices, agriculture. ceramics and metallurgy. For example, protein crystals grown in space allowed the characterization of alpha-interferon and Factor D; both could result in advanced drugs. As a result of another experiment, the encapsulation of pancreatic islets could lead to new treatments for diabetes. The second flight of the Wake Shield Facility demonstrated epitaxial crystal growth in free-flyer mode. The flights of Spacehab-3 and USML-2 included commercial experiments involving protein crystal growth, metal sintering, physiological testing, fluids mixing. biomedical applications. zeolite crystal growth, and plant growth. In protein crystal experiments, an attempt to regulate the growth of the alpha-interferon crystal successfully yielded a more effective formulation for potential 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 on SPACEHAB-3 processed samples for a full hour, a duration essential for providing the defect-trapping information to enable comparisons with sintering processes on Earth. In other FY 1995 experiments, the first completely self-contained plant growth chamber was demonstrated in space: and wheat and mustard plants have shown growth patterns similar to those achieved on Earth. in the natural environment.

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 (CCDS). The four CCDS payloads are: the Commercial Generic Bioprocessing Apparatus (CGBA): the Korund Liquid Phase Sintering metallurgy research the Materials in Devices as Superconductors project: and the Commercial Protein Crystal Growth project. All of these payloads are scheduled for 1996 flights on the Shuttle. 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. 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 1995 activities included 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 response to the Congressionally mandated Launch Voucher Demonstration program (Section 504, Public Law 102-588), on October 19. 1994, NASA identified University of Alabama-Huntsville (UAH) as the voucher recipient for the one launch targeted under OSAT auspices. In June 1995. UAH selected the commercial vendor, EER Systems, on a competitive basis.

In FY 1996, four CCDS payloads will fly on Shuttle-Mir missions: 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 (PCG) projects. both to be flown on STS-79 in August 1996. The CGBA will provide data for the agriculture industry to help improve certain plant characteristics, such as mechanical strength and nutrient content. The Liquid Phase Sintering research will aid in learning how defects are created and trapped during metal processing. The Materials in Devices as Superconductors project investigates new materials which could help revolutionize future generations of electronic devices. The PCG is being flown to characterize additional proteins which will provide new design data for better drugs.

Flight hardware will be fabricated in FY 1996 to be used in KC-135 experiments for the Solidification Design/Thermal Properties Measurement program. These experiments will develop a thermal properties measurement capability for future use on the Space Station to provide improved data for use in solidification design of castings.

The clinical trials of photo-kinetic therapy using a Light Emitting Diode (LED) light source to treat a psoriasis will be concluded in FY 1996.

The SPACEHAB-4 flight in April 1996 is expected to provide float zone single crystals of GaAs and GaSb for advanced electronic applications such as faster computer processing.

Also in FY 1996, the Space Station 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.

A launch is expected to take place in late March 1996 as part of the Congressionally mandated Launch Voucher Demonstration program.

In 1997, the zeolite industry will propose. develop and fly experiments designed to improve the catalytic value of zeolites, which in turn will increase the yield of certain petroleum products from refining.

A multi-use. Space Station-based x-ray diffraction facility is currently being defined. with Phase 11 development expected to start in FY 1997. The facility will produce images of the internal structures of protein crystals grown on the Space Station. allowing rapid characterization and definition of the crystals. The capability to produce this imaging data in space and deliver that data to customers on Earth will be essential to optimize the Space Station's protein crystallography operations, because most crystals start to degrade within a few days after being grown.

The expanded double locker plant growth chamber, which is being built and tested in FY 1996, will be ready to accommodate agricultural industry requirements in FY 1997. The chamber is the product of a cooperative program between the Wisconsin Center for Space Automation and Robotics (at the University of Wisconsin in Madison) and Bioserve Space Technologies (at the University of Colorado in Boulder and Kansas State University in Manhattan). It will be used for applied research exploring phenomena such as lignification of plants and gene splicing to produce superior plant stock for the agricultural industry.

In FY 1997, hardware will be designated for Space Station use for extended measurements of thermalphysical properties of commercial casting alloys. The revision of the Robot Operated Materials Processing System (ROMPS) hardware will be initiated to allow multiple processing of semiconductor materials on Space Station. The design of the Wake Shield Facility will be modified to enable processing over 100 samples on missions involving one shuttle to get into orbit and another to return to Earth.

The Space Processing program plans to work with its centers and their industrial partners to capitalize on the results from initial experiments in completing plans for the commercial utilization of the Space Station. The intent is to focus resources on those applications and processes showing the greatest potential for commercial success.

BASIS OF FY 1997 FUNDING REQUIREMENT

FLIGHT PROGRAMS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Experiment carriers and transporters	2,000	8,100	--
CMAM		8,100	
Launch voucher program	2,000		
Experiment preparation. integration & mission management	1,500	700	
To	3,500	8,800	--

PROGRAM GOALS

The Flight Experiments (IN-STEP) program has been transferred to Spacecraft and Remote Sensing and Space Station Utilization has been transferred to Space Processing in FY 1996. The discussion of these programs is included in the narratives for those budget lines. The remaining activities funded in the Flight programs budget line include: the launch voucher program and an inflatable flight experiment in FY 1995: as well as the Commercial Mid-deck Augmentation Module (CMAM) contract with SPACEHAB, Inc. and the inflatable antenna experiment, both of which are completed in FY 1996. The goal of the CMAM contract is to stimulate industry participation and investment in the commercial development of space by providing additional mid-deck-type accommodations.

ACCOMPLISHMENTS AND PLANS

Of the FY 1995 total funding of $3.5 million, $2.0 million supports the Launch Voucher program. The remaining $1.5 million funds the preparation of the Inflatable Antenna Experiment. The FY 1996 funding will be utilized to complete the CMAM contract and the integration of the Inflatable Antenna Experiment.

BASIS OF FY 1997 FUNDING REQUIREMENT

COMMERCIAL TECHNOLOGY PROGRAM

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Technology dissemination and marketing	10.500	6,600	5,800
Electronic network	1,700	900	1,500
Business practices implementation	19.000	17.100	16,800
Policy, metrlcs and evaluation	2,000	2.000	1.300
Culture change and education	600	800	400
SBIR funding allocation	--	--	-1,600
To	33,800	27,400	24.200

PROGRAM GOALS

The commercial technology program goal is to share the harvest of NASA's technology with the U.S. industrial community. The scope of the commercialization effort includes technologies created at NASA Centers by civil servants and innovations from NASA contractors. The commercial technology program assures that NASA's technology developments, in past as well as current programs, contribute to a significant improvement in the quality of American life and an increase in America's international competitiveness.

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 metrlcs 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 will be fully operational in September 1996, and will include essentially 100% of current, non-sensitive technology activities and opportunities.

The successes of the Commercial technology mission has become a responsibility of every NASA employee, contractor. and partner in industry and academia 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 Officesand Field Centers invest in technology commercialization efforts, and NASA has adopted a target of investing 10-20% of the Agency's R&D budget in commercial partnerships with industry by the end of FY 2000.

MEASURES OF PERFORMANCE

Complete development of performance metrics Plan: September 1995 Accomplished: September 1995	Performance metrics wlll 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.
Implement a detailed general and targeted marketing strategy Plan: October 1995 Accomplished: 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.
100% Inventory of technologies Plan: September 1996 Current: September 1996	Complete inventory of all NASA technologies provides an agency-wide perspective on available NASA technologies and facilitates finding potential partners for ventures.
10% of NASA's R&D budget in commercial partnerships with industry. Plan: September 1996 Current: September 1996	Meets the lower range of National Performance Review goal for the Agency.
Internet-based access to NASA commercial technology database. Plan: September 1996 Current: September 1996	Internet access wlll provide searchable industry and public archives and increase the effectiveness of technology transfer.
Inventory new technology initiated in FY 1997 Plan: October 1997	Keep technology archives updated to maintain maximum relevance to private sector.

15% R&D Investment in Commercial Partnerships Plan: October 1997	Provides assurance that we can meet the upper range of the National Performance Review goal for the Agency.

ACCOMPLISHMENTS AND PLANS

In FY 1995, NASA continued to strengthen the way the Agency commercializes its technology by implementing all aspects of the Agenda for Change. Efforts were geared to establishing an agency-wide metrics system and to initiating documentation of the commercial potential of new technologies and commercial partnerships. The Commercial Technology Education and Training program was developed and its implementation was initiated at the NASA Centers.

In FY 1996, particular focus is on achieving the goal of investing 10% 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. FY 1996 plans also include the completion and demonstration of an automated, on-line, metrics collection system and technology transfer success story database for customer and stakeholder use. Another key activity in FY 1996 will be the completion 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.

In FY 1997, the emphasis will be on continued refinement of the technology and partnership database, updating it to include new agency contracting efforts and to describe new technologies that are to be made public on the electronic network. The Agency will again focus on an overall investment of 15% of the NASA R&D budget in commercial partnerships with industry. In FY 1997, NASA will continue to utilize the E-NET as an electronic marketplace for NASA technology assets, facilitating technology transfer and commercialization opportunities between U.S. industry and NASA.

BASIS OF FY 1997 FUNDING REQUIREMENT

TECHNOLOGY TRANSFER AGENTS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
AdaNET	2.200	2,300	---
Rural state technology transfer center	--	4.500	--
Commercial spaceport activities	--	3,000	
National technology transfer center	9,800	7.300	7,800
SBIR funding allocation	--	--	-500
To	12.000	17.100	7.300

PROGRAM GOALS

Technology Transfer activities utilize technology transfer agents such as the National Technology Transfer Center (NTTC) and Ada "" to facilitate the transfer and commercial use of Federally-sponsored research and technology (and associated capabilities). The increased use of this research and technology will enhance U.S. economic growth and industrial competitiveness.

STRATEGY FOR ACHIEVING GOALS

Since 1990 NASA, in conjunction with other Federal agencies, has funded the NTTC as a national technology transfer and commercialization resource. NASA's 1994 Strategic Review of the NTTC established roles, objectives and guidance for the Center's future operations. In accordance with this review, the NTTC currently provides services to U.S. industry and conducts joint projects with Federal/state agencies that utilize and leverage the core capabilities funded by NASA

The NTTC is managed by Wheeling Jesuit College in West Virginia. The Center is required to implement a comprehensive approach to assessing the performance and impact of its program. Assessments are intended to focus the NTTC on its mission and customer needs, and to enable the continuous improvement of NTTC operations. The assessment approach includes: metrics for "IC operations, measuring key aspects of performance and impact relative to objectives and benchmarks case-studies to illustrate the utility, value and impact of NTTC operations: and third party surveys and focus groups to assess NTTC operations. In addition. NASA will evaluate the NTTC's overall performance as part of the review described above.

In recognition of the dynamic environment for Federal technology transfer and commercialization. NASA will thoroughly review the NTTC program and establish updated guidance and direction for NTTC operations in FY 1996. This review will examine the NTTC's overall effectiveness in fulfilling its mission and roles, and the feasibility of transitioning selected services and activities to full and/or partial cost-recovery operation. The review will support NASA's on-going efforts to strengthen the viability and

effectiveness of the NTTC program. Pending the results of the review, NASA's FY 1997 NTTC funding will focus on four core operational roles addressing needs of the U.S. private sector, NASA and other Federal/state agencies involved in the transfer and commercialization of Federally-sponsored research and technology. The four core NTTC roles are: (1) to serve as a national gateway for Federal technology transfer and commercialization. assisting U.S. industry to locate and access Federally-sponsored technology resources and sources of technical/business assistance: (2) to develop, integrate and utilize national databases to enable efficient access to Federally-funded research and technology resources: (3) to develop and deliver professional-level training in technology transfer and commercialization for Federal agencies and other public and private sector audiences: and (4) to promote U.S. industry awareness of Federally sponsored research and technology resources as well as opportunities and methods for technology transfer and commercialization.

In addition to sponsoring the development of core " " operations, NASA has also fostered the involvement of other Federal agencies through projects that leverage and enhance the NTTC's core roles, capabilities and overall mission. Among the organizations funding projects are the Department of Justice (National Institute of Justice), the Department of Commerce (Minority Business Development Agency), the Department of Defense (Ballistic Missile Defense Organization). and multiple agencies involved in the Administration's National Environmental Technology Strategy.

FY 1996 Appropriations Conference Committee actions provided $4.5 million to initiate a Rural State Technology Transfer Center and $3.0 million for Commercial Spaceport Activities. No additional funds are needed for FY 1997 due to the delays in FY 1996 resulting from the Continuing Resolutions and Government shutdowns.

MEASURES OF PERFORMANCE

The following metrics are applicable to each fiscal year through 1997

Establish annual NTTC plan	By November 1 each year, establish an operating plan incorporating NASA guidance and direction.
Increase Utilization of NTTC	Generate and process 15.000 information and technical requests from U.S. industry to NTTC for the fiscal year.
Provide 6000 annual referrals through NTTC to Government funded technology/business sources	Fully processed requests result in qualified referrals to NASA Field Centers, other Federally-sponsored research and technology resources, or Federal/State sources of technical/business assistance.
Assess NTTC cost effectiveness	NTTC will track the average benefit/cost ratio for technical requests processed by the Gateway service to assess cost effectiveness relative to prior years and to other relevant benchmark.

Increase by 25% Federally-funded research and technology information available via the Internet/World Wide Web	NTTC will Increase public access to Federal research and technology information.

Additional FY 1997 metrlcs:

Transition NTTC training services to full cost-recovery Plan: September 1997	NTTC is to transition during FY 1997 to full cost recovery for on-going training services and programs provided to private and public sector audiences.

ACCOMPLISHMENTS AND PLANS

The Ada "" program has been a successful effort in software reuse. It will be completed in FY 1996. The Rural State Technology Transfer Center and Commercial Spaceport Activities will be initiated in FY 1996 in response to Congressional direction.

NTTC effortshave focused on strengthening the center's capabilities, services and activities in its four core roles. The NTTC continues to handle an increasing volume of technical and information requests from U.S. industry through the center's gateway and World Wide Web/Internet services. providing a robust national access point to Federal research and technology resources. The NTTC gateway service produces qualified referrals to federal laboratories and other Federally-sponsored sources of technology and assistance throughout the Nation. Organizations receiving referrals include NASA, the Environmental Protection Agency, the Departments of Commerce, Energy, Defense and Agriculture, and R&D universities. In support of its gateway and Internet services, the NTTC continues to develop and integrate an unique collection of databases and to implement advanced information tools to efficiently access and utilize the databases. In the area of professional training. the NTTC has worked with NASA, other Federal agencies, and private and public organizations to develop and deliver customized training in technology transfer and commercialization. In addition, the NTTC has conducted a variety of outreach activities with NASA. the Federal Laboratory Consortium for Technology Transfer, and other Federal agencies in order to develop U.S. industry awareness of Federal technology transfer resources and opportunities.

BASIS OF FY 1997 FUNDING REQUIREMENT

ADVANCED CONCEPTS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Concept/technology-driven studies & experiments	(2,000)	4,000	2,500
Challenge-driven studies & experiments..	(1,000)	2,600	1,500
SBIR funding allocation	--	--	-200
To.....	(3,000)	6,600	3,800

PROGRAM GOALS

The Advanced Concepts activity will identify, develop and bring forward new, unconventional. and far-reaching ideas and concepts that may later be applied in advanced technology programs. These fresh. new ideas and concepts will be b e s t e d from outside of NASA as well as from NASA's most promising innovators. Advanced concepts activities will predominantly address NASA strategic objectives requiring technology readiness 10-20 years into the future, as well as highly innovative space applications and commercially enabling space opportunities.

STRATEGY FOR ACHIEVING GOALS

A balanced, dual approach has been developed to achieve the goals of the Advanced Concepts activity. The first part of the approach involves concept/technology-driven projects. which will be fast-paced efforts to define and assess a number of specific new concepts, ideas, and inventions that have the potential to revolutionize our future in space. Examples of concept/technology-driven projects include: magnetically levitated space launch catapults, removal of orbital debris from space via lasers, In-space transportation without propellants via tethers, gossamer structure spacecraft for remote delivery of energy to commercial space facilities or developing nations, and extremely large aperture thin film space telescopes and antennas. These projects will be pursued principally via competitively selected, rotating, two-year Advanced Concepts Research Program (ACRP) cooperative agreements led by world-class principal investigators to be designated "ACRP Fellows". The ACRP fellows will be linked together via Internet resources into a multidisciplinary team, which together with our in-house team, will form the backbone of our Advanced Concepts expertise.

The second part of the Advanced Concepts approach involves challenge-driven projects, in which highly desirable, but currently wholly unattainable goals will be tackled head-on to identify new concepts and major advances in technologies needed for their attainment. For example. these challenge-driven projects might focus on ways to reduce the cost of space launch to below $99 per pound, or on propulsion systems which could cut the trip time to Jupiter to less than 2 months or the time to Mars to less than

1 month. Another project might explore the feasibility of mounting a return to the Moon for less than $5 billion. The challenge-driven approach will utilize roundtables and workshops, including well-known non-NASA innovators, to identify desirable challenges and directions. Once identified, the most promising concepts would be carried into definition studies and experiments through the NASA Centers to ACFW Fellows, or other industry and university innovators, in order to determine their feasibility.

MEASURES OF PERFORMANCE

Advanced Concepts Research Projects Plan: 1st Qtr. FY 96 Accomplished:	The Advanced Concepts Research Projects (ACRP) will be initiated via a Cooperative Agreement Notice.
Develop Near Term and Far Term Metrics Plan: 1st Qtr FY 96 Accomplished	Expected Near-Term Examples: Concepts identified, papers published, customer goals supported Expected Far-Term Examples: Concepts accepted/developed by customers. paper citations (advanced concept customers are the NASA enterprises and other development organizations).

ACCOMPLISHMENTS AND PLANS

In mid-FY 1995. the Advanced Concepts program received a small amount of start up funding from within the Space Access and Technology budget. This funding paid primarily for initiation of early concept/technology-driven and challenge-driven projects while the process for outside input was being definitized. A Cooperative Agreement Notice (CAN) to initiate the Advanced Concepts Research Projects program (Fellows) has been issued.

During FY 1996-1997, the projects started in FY 1995 will be completed, and six new two-year ACRP Fellows projects will be initiated each year. New challenge driven projects will be initiated, stimulated by the inputs obtained from roundtables and workshops, and by the ambitious long-range Agency goals established in the NASA strategic roadmaps.

BASIS OF FY 1997 FUNDING REQUIREMENT

SMALL BUSINESS INNOVATION RESEARCH PROGRAMS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Small business innovation research (SBIR)	118,000	116,700	142,200
Small business technology transfer (STTR) pilot program..	5,900	9,000	--
To.....	123,900	125,700	142,200

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 U.S.-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 II 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% 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 W d e d 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 2200 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 recommendations 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 end-to-end electronic solicitation process is serving as a prototype not only within NASA but across the government.

Several other innovations have been implemented in the small business programs in the last year. A detailed. external evaluation of each proposal's ultimate commercial potential is now included in the selection process. In addition, a comprehensive, systematic review of past SBIR projects' post-phase 11, commercial and or mission applications has been initiated. The information from the review will be used to identify critical predictors of commercial viability and, therefore, to increase the effectiveness of the programs. Finally, a new approach is being implemented to focus several subtopics into specific NASA mission applications. The intent is to more closely tie the SBIR activity to the primary mission needs of each NASA enterprise. The pathfinder for this program has been a collection of subtopics in the general aviation program.

The NASA Small Business Technology Transfer Pilot program (STTR) is a three-year program established in 1994. The SITR program, though modeled after the SBIR program and similar in structure and process, is a separately funded activity with important differences in scope. 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 has met Congressional requirements and will be completed in FY 1996.

MEASURES OF PERFORMANCE

The Agency will obtain commercialization metrlcs (revenue, jobs creation) from previous SBIR and *SITR* awardees in order to better measure the success or failure of the program to meet its commercialization objectives.

Select and announce new SBIR Phase I awards resulting from the FY 1994 solicitation Plan: October 1994 Accomplished: October 1994	Meets the requirements of public law.
Select and announce new SBIR Phase II awards resulting from the FY 1994 solicitation Plan: November 1994 Accomplished: November 1994	Meets the requirements of public law.

Complete development and issuance of the FY 1995 STTR solicitation Plan: January 1995 Accomplished: January 1995	Necessary to ensure the success of the FY 1995 research program.
Complete development and issuance of the FY 1995 SBIR solicitation Plan: May 1995 Accomplished 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 Plan: July 1995 Accomplished: July 1995	Meets the requirements of public law.
Implementation of Internet access to SBIR and STTR documents Plan: August 1995 Accomplished 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 Plan: October 1995 Accomplished October 1995	Meets the requirements of public law.
Select and announce new SBIR and STTR Phase 11 awards resulting from the FY 1995 solicitation Plan: November 1995 Accomplished: November 1995	Meets the requirements of public law.

Complete development and issue the FY 1996 STTR solicitation **Plan:** January 1996 Accomplished: November 1995	Necessary to ensure the success of the FY 1996 research program. Issued two months early (November 1995) and closed in January 1996.
Compile commercialization metrics from 30% of previous Phase 11 awardees Plan: February 1996 Accomplished: February 1996	Data collected on the Phase 11 awardees from the previous two years will improve knowledge of the success of the program in actually commercializing technology. This objective has been reduced from 60% in the FY 1996 narratives due to the inherent difficulty of collecting data from the hundreds of SBIR awardees.
Select and announce new STTR Phase I awards resulting from the FY 1996 solicitation Plan: July 1996 Current: May 1996	Meets the requirements of public law.
Complete development and issue the FY 1996 SBIR solicitation **Plan:** May 1996 Current: June 1996	Necessary to ensure the success of the FY 1996 research program.
Select and announce new SBIR Phase I awards resulting from the FY 1996 solicitation Plan: December 1996	Meets the requirements of public law.
Complete development and issue the FY 1997 SBIR solicitation Plan: April 1997	Necessary to ensure the success of the FY 1997 research program.
Select and announce new SBIR Phase I awards resulting from the FY 1997 solicitation Plan: August 1997	Meets the requirements of public law.

ACCOMPLISHMENTS AND PLANS

The NASA SBIR program has contributed to the U.S. economy by fostering the establishment and growth of over 1100 small, high-technology businesses. At least 225 private ventures have been initiated based on NASA SBIR programs. Twenty major participants have produced more than $150 million in new revenues.

In FY 1995, another 413 new SBIR phase I awards and 190 new Phase 11 awards were made. The 1995 STTR solicitation addresses a greater technology base through its expansion from three to five topic areas. There were 30 new *SITR* phase I awards and 12 new Phase 11 awards in FY 1995. NASA continued to increase 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 commercializationmetrics 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.

FY 1997 will include new SBIR Phase I and Phase 11 awards, and continued evaluation of commercial successes and successful applications to NASA programs. The SBIR budget level in FY 1997 is 2.5% of the total Science, Aeronautics and Technology budget, as mandated by law.

Mission
Communication
Services

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1997 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

MISSION COMMUNICATIONS SERVICES

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	page Number
		(Thousands of Dollars)		
Ground networks	273,400	257,700	255,600	SAT 6-4
Mission control and data systems	175.800	153.300	135,800	SAT 6-9
Space network customer service	32,000	30,300	29,200	SAT 6-16
To	481,200	441,300	420,600	
Distribution of P r o m Amount by Installation				
Johnson Space Center	50	--	--	
Marshall Space Flight Center	3,000	3,000	1.300	
Dryden Space Flight Center	15,100	13,900	15,700	
Lewis Research Center	2.000	1,900	2,000	
Goddard Space Flight Center	262,900	226.200	201,800	
Jet Propulsion Laboratory	196,500	194.500	198,100	
Headquarte	1,650	1,800	1,700	
Total	481,200	441,300	420,600	

OFFICE OF SPACE COMMUNICATIONS

MISSION COMMUNICATIONS SERVICES

PROGRAM GOALS

To enable the activities 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 telecommunications services needed to ensure 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 endeavors. As NASA's agent for operational communications and associated Information handling services. the OSC exploits opportunities for more cost-effective telecommunication solutions. by optimizing design of mission systems using common tools and shared resources to advance national economic interests.

STRATEGY FOR ACHIEVING GOALS

The range of telecommunications systems and services provided by NASA's Space Communications program is necessarily very broad. Capabilities are provided to conduct mission operations, enable tracking, telemetry, and command of spacecraft and sub-orbital aeronautical and balloon research flights. Additionally, services and systems are provided to facilitate data capture, data processing, and data delivery for scientific analysis. The program also provides the high speed computer networking, voice and video conferencing, fax, and electronic mail services necessary to administer NASA programs.

These strategic communications functions are provided through the use of space and ground-based antennas and network systems, mission control facilities, computational facilities to determine spacecraft orbit and attitude. command management systems to validate spacecraft commands. data capture and telemetry processing systems, and a myriad of leased interconnecting communications systems ranging from phone lines and satellite links to optical fibers. The program also provides telecommunications scheduling, network management and engineering, pre-flight communications test and verification, as well as flight system maneuver planning and analysis for selected missions. NASA's flight programs are supported through the study and coordination of data standards and communication frequencies to be used in the future.

The Space Communications program provides command, tracking and telemetry data services between the ground facilities and flight mission vehicles and all the interconnecting telecommunications services to link tracking and data acquisition network

facilities, mission control facilities. data capture and processing facilities, industry and university research and laboratory facilities, and the investigating scientists. The program provides integrated solutions to operational communications and information management needs common to all NASA strategic enterprises and the programs formulated to execute them. The OSC is responsible for development of cost-effective communications architectures and end-to-end communications systems. The OSC provides integrated value-added data processing systems. applies data standards to future systems, and reduces costs through economies of scale and standardization. The program also provides the necessary research and development to adapt emerging technologies to NASA communications needs for future flight programs. New coding and modulation techniques. antenna and transponder development. and automation applications are investigated and, based on merit, demonstrated for application to future communications needs. These are all parts of the strategic approach to providing the vital communications services and systems common to all NASA programs.

Some NASA missions have unique telecommunications requirements. Specialized systems are provided to cope with these unique communications needs. The Deep Space Network (DSN) provides the super-sensitive receivers and large antennas required to communicate with the low-power transceiver spacecraft flying in the outer reaches of the solar system. The Space Network's Tracking and Data Relay Satellites (TDRS) can provide communications as required with low Earth-orbital spacecraft that provide science data, such as multi-spectral imaging of the Earth and the stars. Small. transportable systems have been developed to support sub-orbital atmospheric research rocket flights and balloon launches in remote locations where no communications support infrastructure exists. When possible, requirements are met by using commercially available leased systems and services.

Many science or exploration goals require inter-agency or international cooperation in order to be achieved. NASA's Space Communications assets are often provided through collaborative agreement to other U. S. government agencies and commercial space enterprises and international cooperative programs.

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 first launch of Medium-class Explorer (MIDEX), a new class of Explorer spacecraft. is currently scheduled for March 1999. One spacecraft per year will be launched, with the first and every other MIDEX operated from NASA's Goddard Space Flight Center. To minimize operations costs, plans for the MIDEX missions include consolidating the spacecraft operations, flight dynamics and data processing, all into a single multi-mission control center. The control center system will also be used for spacecraft integration and test thereby eliminating the need and cost of spacecraft manufacturers Integration and Test systems. This new ground system will be built on interconnected workstation computers, similar to the very successful architecture of the Small-class Explorer (SMEX) control center.

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.

Planning is underway to consolidate and streamline major support contract senrices in order to optimize space operations. In FY 1996. as an interim measure, a voluntary contractor partnership is envisioned between the major incumbents. Allied Signal Technical Services Corporation and Computer Sciences Corporation. Transition to a performance-based Consolidated Space Operations Contract (CSOC) will be accomplished in FY 1998.

BASIS OF FY 1997 FUNDING REQUIREMENT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Deep space network systems implementations	106.000	101,700	102,900
Deep space network operations	85,100	84,900	87,500
Spaceflight tracking and data network systems implementation..	4.600	5.100	2,400
Spaceflight tracking and data network operations	28,700	21,400	18.600
Aeronautics, balloons, and sounding rockets systems implementation	23,400	19,600	19,400
Aeronautics, balloons, and sounding rockets operations	25,600	25,000	24,800
To	273,400	257,700	255,600

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 fights; and suborbital balloon and sounding rocket flights. Launch, emergency communications, and landing support for the Space Shuttle 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 :HIEV S

The Ground Networks program provides for the implementation, maintenance and operation of the tracking facilities necessary to fulfill the program goals of the NASA Flight Projects. These facilities are comprised of the following elements: 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 Aeronautics. Balloon and Sounding Rocket tracking and data acquisition facilities managed by GSFC: and the Western Aeronautics Test Range (WATR), managed by the Dryden Flight Research Center (DFRC). The AlliedSignal Technical Services Corporation and Computer Sciences Corporation are the primary support service contractors responsible for ongoing engineering and operations of the Ground Networks. The Ground Networks program enables NASA's access to space, and has also enabled key contributions to the scientific community in the areas of solar system exploration, Earth science observations. human space flight, ground and space based astronomical observations and aeronautics research.

Both, the number of missions serviced by these facilities and the needs of the individual missions will increase dramatically over the next several years. As a result, a number of antennas are under development to meet these new requirements, and obsolete systems are being phased out. A general outline of the DSN implementation plan is as follows: In California (at Goldstone) one new 34-meter antenna became operational in FY 1995. another will become operational in FY 1996, and a third in FY 1998. In Australia, one will become operational in FY 1997. In Spain, one will become operational in FY 1998. In addition, as a result of an agreement with the *Army,* two experimental 34-meter antennas were obtained by NASA at Goldstone. These *Army* antennas are a different design than DSN antennas and require extensive modifications to meet DSN requirements. Until these modifications can be accomplished, one of the antennas will be used to track highly elliptical Earth orbiters. The first of these former *Army* antennas became operational in early FY 1996 and is presently supporting the ESA-NASA collaborative Infrared Space Observatory (ISO) & Solar Observatory for Heliospheric Observation (SOHO) spacecraft. The other will be upgraded for deep space operations by 2000.

Also, in FY 1996, a new 11-meter capability for the cooperative Orbiting Very Long Baseline Interferometry (OVLBI) missions will become operational at Goldstone. California; Canberra,, Australia: and Madrid, Spain.

A similar capability is now available at Greenbank, West Virginia, as a result of a joint NASA and National Science Foundation (NSF) project which restored an obsolete 14-meter NSF antenna for the OVLBI programs. Proficiency training is currently underway utilizing the Student Undergraduate Research Fellowship Satellite (SURFSAT). SURFSAT was a beneficial outcome of NASA's educational outreach efforts. It is now an important element in the OVLBI program. These four OVLBI antennas will initially be used for the Institute of Space and Astronautical Science (ISAS) Japanese VLBI Space Operation *Program* (VSOP) spacecraft to be launched in August 1996.

Other new Ground Networks capabilities include a 10-meter antenna at the NSF's McMurdo facility in Antarctica This antenna was installed in FY 1995 and will acquire Synthetic Aperture Radar (SAR) data from the NASA/Canadian Space Agency RADARSAT

spacecraft. An 11-meter antenna is under development for the University of Alaska, Fairbanks (UAF) in FY 1996 for use with the Japanese/U. S. Advanced Earth Observing Satellite mission (ADEOS). An additional three 11-meter antennas are under contract by Wallops Flight Facility (WFF) for use with ADEOS and other NASA missions. One of these 11-meter antennas will be installed at Svalbard, Norway. One will go to the WFF, and the last antenna will go to Fairbanks, Alaska.

Our strategy for achieving the above goals has six major elements: (1) the DSN is the premier facility for tracking deep space probes. It is occasionally supplemented by the facilities of other agencies or nations (e.g., the Australian Parkes radio telescope antenna will complement DSN coverage of Galileo); however, there is no other overall source for this type of tracking. Therefore, in the absence of other sources, NASA will continue to provide this capability: (2) there are a number of present and future Earth resource observation missions, the communications needs of which can be partially or completely serviced by commercially available systems. NASA will obtain these systems from U. S. industry on a competitive basis; (3) NASA is actively working with industry to foster the enhancement of existing 'commercial-off-the-shelf" systems to expand their applicability so that inexpensive and reliable telecommunications services can be readily obtained for the new small and less expensive missions. In the future, these missions will be supported by small, inexpensive, commercially available tracking systems: (4) the Ground Networks Program, in conjunction with other NASA elements, is demonstrating and implementing Global Positioning System (GPS) flight units on NASA sponsored missions. This demonstration will seek to minimize future tracking and navigation activities, thus lowering costs. Two planned flights, Lewis and Student Nitric Oxide Explorer (SNOE), will provide a fully operational demonstration of these new capabilities using commercial flight units as the primary source of this function: (5) interagency activities, as alluded to above, are possible which enhance NASA's capabilities: and (6) the WATR is striving for even more efficiency as it provides NASA's capability for tracking and telecommunications of increasingly complex aeronautical research test flights on the Western Aeronautics Test Range. In addition to servicing NASA's research aircraft, the WATR also provides tracking and telemetry services for Space Shuttle landings at Edwards Air Force Base.

The following cost reduction initiatives are underway:

- The cost of operating the DSN is being reduced through re-engineering efforts now in process. These new processes will allow the DSN to double the tracking hours delivered while reducing the cost of these processes by more than half. The processes to be implemented include: (1) moving toward giving the operators end-to-end control of the entire data acquisition process, (2) redesigning systems that provide support data to allow automation and quicken response time, and (3) developing a process to better define DSN services and allow customers to choose the services necessary to support the mission.

- Efforts to reduce the cost of operations for low-Earth orbit spacecraft are also underway with the development of new technology and operational processes. The goal of these efforts is to provide turn-key mini-systems which can be operated directly by the flight projects. This concept will be validated by the Lewis Project and SNOE Project in the near future.

- Re-engineering efforts will continue on the STDN facilities to reduce their operations and maintenance costs. It is our intent to close the Bermuda STDN station. following completion of two planned Space Shuttle modifications. One will permit earlier communications through TDRS during the launch phase of the mission and the second will allow onboard use of the Global Positioning System (GPS) to replace the use of ground radar for Shuttle navigation. We anticipate Bermuda station closure

occurring in FY 1998. Similarly, obsolete WATR systems will continue being replaced with state-of-the-art systems that are more reliable and have lower maintenance requirements. Technology advancements have made the standard features of these replacement systems capable of meeting the increasingly more complex aeronautical research requirements on the WATR.

-- Beginning in FY 1998, it is our intent to procure commercial tracking services for those Earth Orbiter missions serviced by the DSN. Transition activities to the commercial operator and phase down of DSN 26-meter antenna subnet operations are expected to begin in FY 1997. Upon successful completion of transition activities, NASA will cease operation of the DSN 26-meter subnet. The DSN will return to servicing *only* deep space missions and ground based radio astronomy and planetary radar astronomy activities.

MEASURES OF PERFORMANCE

	FY 1995		FY 1996		FY 1997
	Plan	Actual	Plan	Current	
Deep Space Network					
Number of NASA missions supported	45	43	46	46	45
Number of hours of service	64,000	57,000	70.000	73,000	93,000
Spaceflight Tracking and Data Network					
Number of STS launches supported	7	6	7	7	7
Number of ELV launches supported	13	20	12	10	6
Wallops Flight Facility					
Number of NASA Earth-Orbiting missions supported	25	24	26	30	30
Number of Sounding Rocket deployments supported	40	30	40	28	30
Number of Balloon deployments supported	29	22	29	22	22
Number of hours of service (Wallops Orbital Tracking)	32,000	27,200	31.000	31,000	31,000
Western Aeronautical Test Range					
Number of NASA missions supported	1,100	1,472	1,100	1,790	2.236
Number of NASA research flights supported	500	520	500	620	780

The decrease in the DSN hours of service in FY 1995 was due to unplanned major maintenance on the 70-meter subnet, and termination of Mars Observer. Clementine and Magellan missions. In addition, the decrease was further realized by launch delays for missions such as the Total Ozone Mapping Spectrometer (TOMS), the SMEX, and the International Solar Terrestrial Physics (ISTP). The increase of Expendable Launch Vehicle (ELV) launches was a result of commercial and Department of Defense (DoD) launches. WFF hours of service for orbital tracking declined due to the demise of the Cosmic Background Explorer (COBE), as well as launch delays such as the Fast Auroral Snapshot Explorer (FAST) and the TOMS. The increase in the number of NASA missions

and research flights supported at the WATR was attributed to an increase in the scope of work for X-31 flights supporting DoD activities, and additional X-31 low altitude, hi-alpha envelope expansion flights.

ACCOMPLISHMENTS AND PLANS

In FY 1995. the Space Shuttle missions were successfully supported through dedicated facilities of the STDN. The two major requirements for the STDN are always. without exception. 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 during the launch phase. Both of these requirements were met 100% of the time.

During FY 1996. the Galileo spacecraft reached Jupiter and began its tour of the Galilean moons. Antennas at the DSN stations and the Parkes Radio Telescope will be arrayed to enable a greater return of Galileo science data over the next 2 years, despite the spacecraft's high gain antenna failure. In the area of educational outreach, NASA is working with 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. One of the center pieces of this project will be the ability of students to utilize a DSN antenna to conduct experiments beginning in FY 1996. The antenna, obsolete from the point of view of spacecraft tracking, will enjoy a second life as an instrument for education.

In FY 1997. the DSN will service or prepare to service flight missions studying the Sun, Asteroids. the Moon. Mars, Jupiter, and Saturn. Contact with other spacecraft. which have left the solar system and are billions of miles from Earth, will also continue to be provided. For example, radio signals, traveling at the speed of light, require over 17.5 hours to travel from the Deep Space Network antennas to the Pioneer 10 spacecraft and back *again,* making the DSN the provider of mankind's longest two-way communications capability. In addition, the ability of the DSN to conduct radar surface mapping of planetary objects will enable the examination of many objects in the solar system, including Earth-Approaching Asteroids and Comets, similar to the one thought to be responsible for the extinction of the dinosaurs.

Low and sub-orbital flight mission services will be provided by permanent and transportable tracking facilities. These facilities will service low-Earth orbit, sounding rocket, and atmospheric balloon missions. The data recovered from these missions will contribute to science areas such as astronomy, astrophysics, atmospherics, geophysics, and Earth observations and mapping.

Significant work to be completed at the Western Aeronautical Test Range in FY *1997* includes refurbishing the DFRC radar systems: continuing replacement of the graphic display in the mission control center for faster, higher resolution data presentation: and a major overhaul of DFRC telemetry antennas.

BASIS OF FY 1997

MISSION CONTROL AND DATA SYSTEMS

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Mission control systems	12.000	10.300	9,300
Mission control operations	52.500	45,300	41,700
Data processing systems	42.300	38,300	30,900
Data processing operations	69.000	59.400	53.900
To	175.800	153.300	135.800

PROGRAM GOALS

To provide reliable, cost-effective mission control and data processing systems and services for space flight missions of the 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, managed by the Goddard Space Flight Center, is comprised of a diverse set of facilities, systems, and services required to support NASA flight systems. The Computer Sciences Corporation and AlliedSignal Technical Services are the support service contractors responsible for ongoing engineering support, development, operations, and maintenance.

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 (MCC) 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, and system performance. Real-time management 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 (MOC's) for the HST, the several missions of the ISTP program, International Ultraviolet Explorer (IUE), TOMS, and SMEX programs: and the Multi-satellite Operations Control Center (MSOCC) that serves the Compton Gamma Ray Observatory (CGRO), Upper Atmospheric Research Satellite (UARS), Extreme Ultraviolet Explorer (EUVE), Earth Radiation Budget Satellite (ERBS), and International Cometary Explorer (ICE).

UARS will be the last satellite controlled by the aging Multi-satellite Operations Control Center. The EUVE 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), and Submillimeter Wave 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), ISTP/Polar and ISTP/SOHO have been completed. Tropical Rainfall Measuring Mission (TRMM) and Advanced Composition Explorer (ACE) control centers are in development. These workstation systems will allow for Increased mission control capability at reduced cost.

Other mission control systems include the Space Shuttle POCC Interface Facility (SPIF) and the Command Management System (CMS). 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 deployed by the Shuttle. 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-fight 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 and quantity of 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, the Data Distribution Facility (DDF), and the Telemetry Processing Facility. The PACOR facility utilizes the international Consultative Committee for Space Data Systems (CCSDS) data protocol to facilitate a standardized method of supporting multiple spacecraft. The PACOR system was upgraded to a distributed workstation environment in FY 1995 in order to manage the increasing volume and rate of processing. PACOR provides a cost-effective means of processing flight data from the following spacecraft missions: SAMPEX, EUVE, CGRO, SOHO. SWAS, XTE, TRMM, and HST.

The Data Distribution Facility performs electronic and physical media distribution of NASA space flight data to the science community. The Data Distribution Facility has been a pioneer in the use of Compact Disk-Read Only Memory (CD-ROM) technology for the distribution of spacecraft data to a large number of NASA customers.

Specialized data processing services are provided by the Telemetry Processing Facility for the ISTP missions, and the Spacelab Data Processing Facility (SLDPF) located at the Marshall Space Flight Center (MSFC) processes data from Space Shuttle payloads. Specialized telemetry processing systems for NASA's Space Network are also provided under this program.

The Mission Control and Data Systems program also provides for the operation, sustainment, and improvement of NASA's Flight Dynamics Facility (FDF). The FDF provides orbit and attitude determination for operating NASA space flight systems. including the TDRS and the Space Shuttle: develops high-level operations concepts for future space flight systems: modifies existing FDF systems to accommodate future missions: develops mission-unique attitude 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.

Besides the operation of currently deployed spacecraft and the modification and development of mission control and data processing systems to accommodate new 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 systems designs that 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.

The Mission Control and Data Systems program supports advanced technology development at the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory. The GSFC team, including contractors and universities provides advanced technology in several areas, such as tracking and data acquisition future systems: communications and telemetry transport: and advanced space systems for users. The JPL team advances technology in multiple areas such as spacecraft radio systems development and optical communications development: communications systems analysis: and flight demonstrations. The Mission Communication Services advanced technology development, supported by NASA's Mission Control and Data Systems, is of two forms: near term (1-3 years) demonstration and application of data management and telecommunications technology and procedures: and more long-range (3-5 years) development of ground and space flight communications systems. Consideration of innovative applications of commercial "off-the-shelf" technology is emphasized. Such applications often open new market opportunities to suppliers of these technologies resulting from their NASA experience.

Finally, a critical element of the Mission Control and Data Systems program is the securing of adequate frequency spectrum resources which are required in the performance of all flight missions, manned and unmanned. NASA's Office of Space Communications coordinates frequency spectrum requirements with other federal agencies. industry and regulatory bodies such as the International Telecommunications Union obtaining all requisite authorization to operate telecommunications systems associated with its flight programs. *Also.* consistent with its charter pursuant to both the Space Act of 1958 and the Communications Satellite Act of 1964. NASA is the primary advocate, both domestically and internationally. for obtaining the unique frequency spectrum allocations required by the commercial sector to exploit satellite technology for future generation telecommunications systems to ensure continued U.S. global dominance. In compliance with the 1992 Telecommunications Authorization Act, the Agency actively participates in the Interdepartment Radio *Advisory* Committee, working with National regulators such as the Federal Communications Commission and the State Department in establishing both National and International spectrum management policies.

MEASURES OF PERFORMANCE

	FY 1995		FY 1996		FY 1997
	plan	Actual	Plan	Current	Plan
Number of NASA spacecraft supported by GSFC mission control facilities	18	11	19	16	17
Number of mission control hours of service	40,000	39.500	40,000	50.000	52,000
Number of billions of bits of data processed	12,200	10.000	15,500	13,500	12,000
Number of NASA missions provided flight dynamics services	29	32	30	34	33

New spacecraft launches e.g. SOHO. SWAS. XTE, were rescheduled to later years resulting in a reduced level of NASA spacecraft supported by GSFC mission control facilities and causing a reduction in the number of billions of bits of data processed as well as a reduction in the number of mission control hours of service. The increase in the number of NASA missions that were provided flight dynamics services is slightly higher than planned based on two more ELV launches and one more STS launch than planned.

ACCOMPLISHMENTS AND PLANS

In FY 1995. the Mission Control and Data Processing programs have pursued proactive measures to consolidate functions, close marginal facilities, and reduce overall contractor workforce to reflect the Agency's goals. Examples of this are the closure of the GSFC SLDPF and subsequent transfer of that function to the MSFC. This action reduced the cost of Spacelab data processing by more than 50%. The closure of the Magnetic Tape Certification Facility saved more than $2 million per year.

During FY 1995, mission control was performed for the HST, CGRO, UARS, EUVE, IUE, SAMPEX, ICE, Interplanetary Monitoring Platform (IMP-8) ERBS, TOMS-Meteor, and ISTP/WIND. In early FY 1995, the WIND spacecraft was deployed under the control of Goddard Space Flight Center's (GSFC) mission control facilities.

Packet data processing operations were provided for the HST, CGRO, EUVE, and SAMPEX. The time division multiplexed (TDM) services were provided for the Geomagnetic Tail (GEOTAIL), UARS, ERBS, ICE, IMP-8, National Oceanic and Atmospheric Administration (NOAA)-10, and WIND missions, and will continue for the POLAR mission upon its deployment. Data processing of the Spacelab missions at MSFC was performed.

Orbit determination of the TDRS itself was provided, and Flight dynamics services were provided to all NASA space flight missions that utilize NASA's Space Network and to selected elements of the Ground Network, including the Space Shuttle, expendable launch vehicles (ELV), and satellite systems. A new operations concept for flight dynamics was developed. The new concept defines an approach to reduce flight dynamics costs by implementing new technology.

In FY 1995, reimbursable support for the Geostationary Operations Environmental Satellite (GOES)-Next and four commercial ELV deployments was performed. In addition, the Global Positioning System (GPS) Enhanced Orbit Determination System for the Lewis mission was started.

Among systems implementation projects in FY 1995. development of TPOCC systems for the upcoming FAST, SWAS. SOHO. and XTE spacecraft were completed, including the procurement of workstations, processors. and software. TOMS-EP is in the process of being integrated into the TOMS mission control center. FAST and SWAS mission control systems were combined into a generic SMEX mission operations center. Modifications of the Command Management System for the SOHO mission was also supported. TPOCC development for the CGRO and EUVE missions continued in order to allow closure of the aging MSOCC facility by FY 1997. Preparations for the Second Servicing Mission for the HST began and will accelerate through FY 1997 with ground system software changes being made to accommodate the planned new space systems.

The spacecraft managed by GSFCs mission control facilities are supported by various NASA communications networks, including the TDRSS, the Deep Space Network (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. 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.

In FY 1995, transfer of data systems technologies to flight project use occurred in the areas of software reuse, Very Large Scale Integration (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. The Mission Control and Data Systems programs will continue to integrate modem technology into mission operations support systems through the use of systems like the Generic Spacecraft Analyst Assistant (GenSAA) for automation, software based telemetry front-end processing systems, the Mission Operations Planning and Scheduling System (MOPS), and exploring the use of case based reasoning tools.

In support of Advanced Technology Development, planning and implementation began in 1995 on demonstrating optical laser communications between the ground and an Earth-orbiting spacecraft using the JPL ground facilities and the Japanese ETS-VI

satellite. Also. a contract was placed for a 4th generation lightweight, low power consuming radio transponder for users of the TDRSS.

NASA continues to exercise its responsibilities for Space Communications in a cooperative manner with our international partners. In FY 1995, we continued strategic planning panels with European Space Agency and the National Space Development Agency (Japan) and instituted new relationships with the French Centre National d'Etudes Spatiales and German Aerospace Research Establishment organizations. We also established the groundwork for similar panels with the Russian Space Agency to begin in FY 1996.

NASA actively supported the U. S. objectives in the 1995 World Radio Conference: additional preparations are underway continuing this work for both the 1997 and 1999 World Administrative Radio Conferences both in domestic and international forums. The Agency also successfully convened an Industry/Government workshop during FY 1995 addressing critical spectrum issues associated with national implementation of Space Sensing Satellite Systems.

During FY 1996, conversion of CGRO and EUVE to TPOCC systems will be completed, permitting the closure of the MSOCC facility in FY 1997.

Attitude software and simulator development is being provided for the SOHO. XTE, SWAS. FAST, TOMS-EP. Transition Region and Coronal Explorer (TRACE), Wide-field Infrared Explorer (WIRE), ACE, TRMM. EOS-AM. and Landsat-7 flight systems. Transitioning the FDF to a workstation environment will continue through FY 1997.

The XTE, SWAS, and SOHO missions will be supported by GSFCs data processing program in FY 1996.

Operational orbit determination for the SOHO. XTE, SWAS. FAST, and TOMS-EP will be added in FY 1996. and reimbursable support will be provided for seven missions. including the Lunar Prospectors, Satellite de Applicaciones Cientificas-B (SAC-B), GOES, and NOAA programs. Support for the POLAR mission will begin in FY 1996 and for the ACE and TRMM missions in FY 1997. Mission planning for the future missions such as ACE, TRMM, TRACE, WIRE. Far Ultraviolet Spectroscopic Explorer (FUSE), Landsat-7, and Earth Observing System (EOS) will be performed.

The Office of Space Communications has been laying the ground work for future streamlining of operations through the development of communication interface standards that will lower cost by eliminating unique communication system interface protocols and is being conducted in joint cooperation with the Department of Defense as well as with other international space agencies. The first version of a new space communication protocol standard, developed jointly with the Department of Defense and British Defense Research Agency, will be test flown on the Space Technology Research Vehicle (STRV) satellite in early 1996. These new communication protocols will be based on internet protocols with necessary modifications for the space to ground telecommunication environment.

Advanced technology is being furthered in all work areas. The 4th generation TDRSS radio transponder engineering unit is anticipated in FY 1996. Work on deep space radio transponders and data coding technology continues. The laser communications demonstration continues for the duration of the ETS-VI satellite lifetime which is now estimated to end 29 FY 1996.

FY 1997 will be a transitional year for many aspects of the Mission Control and Data Systems program. Mission Control and Data Systems will provide Mission Control Flight Dynamics and Data Processing service for the TRMM and ACE missions scheduled to be launched in FY 1997. The SAMPEX missions will commence transfer of operations to the University of Maryland. and plans for the EUVE mission to transfer operations responsibilities to the University of California, Berkeley are in process. Support to ICE and IMP-8 will end, and the MSOCC ERBS facility will close. Significant development, test, and prelaunch support associated with MIDEX, and the SMEX missions. WIRE and SMEX LITE, will compose a significant portion of the Mission Control and Data Systems activity.

The ACE and TRMM mission control centers will be completed in FY 1997, and the ACE mission will be added to the data processing operational workload. Emphasis upon artificial intelligence applications and advanced graphical displays will be accelerated in FY 1997 for application in MIDEX and future SMEX missions. 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.

During FY 1997. the HST Second Servicing Mission will be conducted from the HST control center; and transition to support of the next series of SMEX missions will begin. Development efforts will take place in preparation for the future TRMM, Transition Region and Coronal Explorer (TRACE), Wide-field Infrared Explorer (WIRE), and MIDEX missions.

To promote operations automation in FY 1997, Mission Control and Data Systems will intensify development efforts on the EWE APOCC (Automated POCC) and the CGRO Reduced Operations by Optimizing Tasks and Technologies (ROBOTT) effort. Mission Control and Data Systems will actively lead and participate in establishing Renaissance directions and rapid prototyping. exploring system autonomy concepts, and use of commercial-off-the-shelf (COTS) products (such as demonstrated in the FY 1995 COTS Integrated Monitoring, Analysis, and Control System (IMACCS)).

To continue providing leadership in promoting Center and Agency-wide participation in operations automation, Mission Control and Data Systems will take the lead in scoping and prototyping Mission Operations Control Architecture (MOCA) elements such as the use of Transmission Control Protocol/Internet Protocol (TCP/IP) or Space Communications Protocol Standards (SCPS) for ground and flight communications. the use of knowledge based control languages, ground and space autonomy, and active participation in the American Institute of Aeronautics and Astronautics (AIAA) Spacecraft Control Working Group to infuse emerging operations standards in the areas of satellite control. Exploration of the promise of advanced communications technologies will continue throughout this period.

Several exciting events are anticipated during FY 1997. A flight demonstration of the 4th generation radio transponder engineering unit, and breakthroughs regarding new coding techniques such as turbo codes, to enable efficient, reliable use of the frequency spectrum over planetary distances, are planned.

BASIS OF FY 1997 FUNDING REQUIREMENT

SPACE NETWORK CUSTOMER SERVICES

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Space network customer services.....	32,000	30,300	29.200

PROGRAM GOALS

To provide reliable, cost-effective customer access to the multi-mission space telecommunications network serving all TDRS-compatible Earth orbiting and suborbital flight missions and to coordinate and provide network control and scheduling senrices to customers of both the Space Network and selected Ground Networks elements.

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

This program develops and maintains the interfaces required by users of the Space Network. The Network Control Center (NCC), located at the Goddard Space Flight Center in Maryland, is the primary interface for all user missions. The NCC provides user scheduling, ground terminal and satellite configuration, and fault isolation services for the network In addition, the program provides comprehensive mission planning. user communications systems analysis, mission analysis, network loading analysis, and other testing services to insure network readiness and technical compatibility for in-flight communications.

These services are provided by support service contractors who operate, maintain. and modify the NCC, the Simulations Operations Center (SOC). and other support and analytical systems providing senrices to the customer missions and to the network. The Computer Science Corporation provides the primary systems engineering. software development. software maintenance, and analytical services. Allied Signal Technical Services Corporation provides operations and maintenance personnel as well as some specialized engineering. analysis, and software tasks.

This program also undertakes network adaptations to specific user needs and provides assistance to test and demonstrate emerging technologies and communications techniques. Funding is provided to operate and maintain a remote terminal in Australia which. in concert with the TDRS-3 spacecraft, enables a greater science return from the Compton Gamma Ray Observatory following the failure of its on-board tape recorder. The TDRS spacecraft are also being made available to industry for

test and demonstration of new technology for a variety of mobile satellite system services, 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 NOAA ocean buoy data collection, and NSF Antarctic data collection. A series of tests with future Japanese and European missions and data acquisition systems will be conducted to explore interoperability with the Space Network for emergency operational support of NASA spacecraft.

MEASURES OF PERFORMANCE

	FY 1995		FY 1996		FY 1997
	plan	Actual	Plan	Current	
Number of NASA spacecraft events supported by the NCC	63,700	56,400	68,700	60,800	59,400

The actual number of events supported by the NCC in FY 1995, and the plan for FY 1996 reflects changes in operational contacts for Compton Gamma Ray Observatory (CGRO) and TOPEX launch delay of XTE and a reduced Shuttle flight rate.

ACCOMPLISHMENTS AND PI

In FY 1995, the NCC software was modified to provide the ground station interface the capability for operation of more than three TDRS spacecraft. This capability. in conjunction with the dual ground station at the White Sands Complex. will allow partially failed TDRS spacecraft, with remaining service capability, to provide communications service to customer satellites. This capability will defer the need to launch additional TDRS spacecraft until the first of the replenishment satellites are available.

Plans for FY 1996 include initiation of development of an improved, distributed architecture scheduling system for the NCC. When completed, this system will provide more efficient use of the network capabilities and improved ability to resolve scheduling conflicts among user missions. In addition. a cooperative effort, jointly funded with the Ground Networks, will develop a radio frequency interface to the Space Network for deployment in Antarctica. This capability will allow rapid retrieval of science data from the Canadian RADARSAT for data validation where no practical commercial satellite communications services exist, and is potentially applicable to other polar orbiters with near real-time data retrieval requirements. Studies will be undertaken to explore establishment of a more robust remote terminal capable of full service provision to users in the TDRS zone of exclusion. The development of a compact transponder, using new technology. suitable for use by new, small satellites will be initiated this endeavor will provide an engineering model and a small number of flight units to be provided to upcoming flight projects. expanding Space Network/TDRS use to a new class of missions. The Office of Space Communications funding for the Compatibility Test Van (CTV) operations will be discontinued after FY 1996 and support contractor efficiencies initiated in FY 1995 will continue.

In FY 1997, continued downsizing efforts effect support contractor levels in engineering support, hardware and software maintenance, and other technical services. Requested funding will provide for continued operations, maintenance, and modification of the NCC, and other customer support systems and services. NCC modifications to the scheduling system will continue, incorporating standard commercial protocols into the control center interfaces. The Radio Frequency Simulations Operations Center (RFSOC) operations are planned to be discontinued at the end of FY 1997. Small satellite transponder and antenna systems technology development will continue.

Academic
Programs

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCALYEAR 1996 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	page Number
	(Thousands of Dollars)			
Education	57,900	58,500	54.900	SAT 7.1-1
Minority research and education	48.300	48.400	45.900	SAT7.2-1
To	106.200	106.900	100.800	

Education
Programs

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1996 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	Page Number
	(Thousands of Dollars)			
Student programs	11.200	10.400	10.000	SAT 7.1-3
Teacher/faculty	14300	14.800	14,000	SAT 7.1-6
Systemic change	26,400	26.400	24,800	SAT7.1-9
Education technology	5.500	6.200	5.400	SAT 7.1-12
Evaluation	500	700	70Q	SAT7.1-14
Total	57.900	58.500	54.900	
Distribution of Program Amount by Installation				
Johnson Space Center	435	998	954	
Kennedy Space Center	289	631	603	
Marshall Space Flight Center	2.503	3.084	2.948	
Stennis Space Center	938	1.293	1.236	
Ames Research Center	2.405	3.626	2.763	
Dryden Flight Research Center	22	44	42	
Langley Research Center	478	998	954	
Lewis Research Center	374	910	870	
Goddard Space Flight Center	696	1.182	1.130	
Jet Propulsion Laboratory	1.147	1.147	1,096	
Headquarters	48.613	44.587	42.304	
Total	57.900	58.500	54.900	

ACADEMIC PROGRAMS

EDUCATION PROGRAMS

PROGRAM GOALS

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 National Science and Technology Council/Committee on Education Technology (NSTC/CET) 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 Program uses 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. Programs reach students, teachers and faculty at all educational levels with opportunities for students to explore their Interest In science, mathematics, engineering, and technology: workshops for teachers to enhance their content knowledge: and opportunities for faculty to participate in NASA-sponsored research activities at NASA field centers.

The *key* goals for NASA's Education program *are:*

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 educatlon initiatives that specifically address NASA mission requirements, national education reform, and NSTC/CET priorities:

Expand significantly the Impact of the NASA Education program by developing partnerships with *key* external constituencies: and

Implement an agency-wide education program and evaluation framework, to bring organization, focus and accountability to the agency's efforts in education.

Programs are organized within a framework that Inter-relates NASA mission content and all parts of the educational pipeline with various implementation approaches. Within this framework. programs *are* divided into five categories (which describe the Implementation approaches): student, teacher/faculty preparation and enhancement, support of systemic change, curriculum support, and education technology. In addition. evaluation is a process that cross cuts the five categories.

BASIS OF FY 1997 FUNDING REQUIREMENT

STUDENT PROGRAMS

	FY 1995	FY 1996	FY 1997
	(Thousands of Dollars)		
Elementary and secondary	3.700	2,900	2,800
Higher education	7.500	7.500	7.200
To	11.200	10.400	10.000

PROGRAM GOALS

The goals of the Student Programs are: to provide experiences and exposure to NASA's mission; to provlde research experiences for students at NASA and related sites: and to provide support to train students in science, mathematics. engineering and technology.

STR 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. Activities such as the Space Science Student Involvement Program (SSIP) and the Shuttle Amateur Radio Experiment (SAREX) provlde general exposure to NASA's mission and stimulate interest 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 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 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) provide support to train students in NASA-related disciplines at both the master's and doctoral levels.

A core objective at all levels of student programs 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 1995 Actual	FY 1996 Estimate	FY 1997 Estimate
Space Science Student Involvement Program (SSIP)			
Materials distributed	250,000	250.000	250,000
Entries/proposals (student participants):	9,000	9,000	9,000
Teacher participants:	1,000	1,200	1,000
National awards:	14	14	14
States participating:	50	50	50
SHARP/SHARP-PLUS			
Student participants:	500	500	500
SAREX			
Student participants:	10,000	10,000	10,000
Higher Education			
GSRP			
Student participants:	436	510	436
Universities:	110	117	110

Currently, program activities in the above categories have a variety of evaluation mechanisms. In FY 1996, 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

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 1995. the *SHARP* and SHARP-PI JS program encouraged more than 500 underrepresented minority high school students to participate in intensive research apprenticeships with NASA and active industry and university scientists and engineers.

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 1995. more than 250,000 students were reached by materials distributed to elementary and secondary schools, providing opportunities for 1,000 teachers and 9,000 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.

The Shuttle Amateur Radio Experiment (SAREX) provides students the opportunity to participate directly in the Shuttle program through the use of technology. Through actual communication with Shuttle astronauts via amateur radio, and supporting activities. students gain first-hand knowledge of the Shuttle program and its science objectives. During FY 1995. more than 10,000 students were involved and the program is expected to include approximately the same number of students in FY 1996 and FY 1997.

Higher Education

At the Higher Education level, the GSRP, initiated in FY 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 450 graduate students pursuing the masters or doctorate degrees in science, engineering, mathematics, and technology. The request in FY 1996 and FY 1997 for Higher Education will maintain the fellowships close! to the current level.

BASIS OF FY 1997 FUNDING REQUIREMENT

TEACHER/FACULTY PROGRAMS

	FY 1995	FY 1996	FY 1997
	(Thousands of Dollars)		
Elementary and secondaxy	4,600	5.200	5,000
Higher education	9,700	9,600	9,000
To	14,300	14,800	14,000

PROGRAM GOALS

The goal of the Teacher/Faculty Preparation and Enhancement Programs 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 are designed to utilize the NASA strategic enterprises and the process by which new knowledge is discovered to 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: and provide access to and promote utilization of NASA related materials and information resources. Programs such as NASA Education Workshops for Elementary School Teachers (NEWEST), NASA Education Workshops for Math and Science Teachers (NEWMAST), 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 through workshops around the country. The backbone of these teacher enhancement workshops continues to be the curriculum support materials developed through the Teaching From Space Program.

Higher Education

At the higher education level, activities are designed to enhance faculty research skills and content knowledge; 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.

A core 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 1995 Actual	FY 1996 Estimate	FY 1997 Estimate
NEWEST/NEWMAST			
Teachers	215	265	250
UCEP			
Teachers	770	770	800
Teacher Enhancement Workshops			
Teachers	250	500	300
Higher Education			
Summer Faculty Fellowship program			
Fellowships	314	314	300
Colleges/universities	196	196	180
JOVE			
Faculty members	162	178	162
Institutions	89	95	89
Innovative Research			
Research grants	22	22	22

Currently. program activities in the above categories have a variety of evaluation mechanisms. In FY 1996, 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.

IPLISHMENTS ANS

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.

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 1996 will be 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 night 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 89 academic institutions participating, most of whom had little previous contact with the Agency.

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 1996 and FY 1997 funding for Higher Education will provide for continuation of ongoing projects and a limited number of new awards.

1 OF FY 1997 FUNDING REQ[redacted]

SUPPORT FOR SYSTEMIC CHANGE

	FY 1995	FY 1996	FY 1997
	(Thousands of Dollars)		
Aerospace education services program (ASEP)	6,200	6,200	6,100
National space grant college and fellowship program	14,600	14,600	13,600
Experimental p r o m to stimulate competitive research (EPSCoR)	4,900	4,900	4,500
Innovative reform initiatives	700	700	600
To	26,400	26,400	24,800

PROGRAM GOALS

The goal of the Support for Systemic Change program is to enhance capabilities of the educational community through individual/collaborative efforts with a range of partners and/or through infrastructure changes.

STRATEGY FOR ACHIEVING GO—

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 p r o m at the elementary and secondary education level is the Aerospace Education Services Program (AESP). 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.

Higher Education

Systemic Change activities at the higher education level enhance the research and educational capabilities of the higher education community through activities conducted via partnerships, linkages, and collaborations: and enhance the collaborative capabilities of a diverse set of academic institutions. Programs such as Space Grant, EPSCoR, and M-State play a major role in NASA's contribution toward the Nation's systemic educational reform movement.

The Space Grant program was authorized by Congress in 1987 to increase the understanding. assessment, development, and use of space resources. All 50 states, Puerto Rico. and the District of Columbia have Space Grant Consortium programs in which more

than 550 institutions participate. These consortia form a national network of colleges and universities with interests in aerospace research, training, and education. 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 Space Grant program, 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. The NASA EPSCoR 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 capabilities 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 may be one of leadership, being a participant, or acting as a facilitator to empower and enable wide reaching educational reform that is systemic in nature. An example of these partnerships is the Tri-State Education Initiative.

MEASURES OF PERFORMANCE

	FY 1995 Actual	FY 1996 Estimate	FY 1997 Estimate
AESP			
Schools visited	1.300	2,000	1,500
Teacher workshops	1,650	2,500	2,000
Teachers	18,000	19,000	18,500
Space Grant			
Consortia	52	52	52
Institutions	550	550	550
EPSCoR			
Awards	6	14	10
Innovative Reform initiatives			
Public School Systems	30	45	30
Schools	346	460	350
Students	150,000	200,000	150,000

Currently. program activities In the above categories have a variety of evaluation mechanisms. In FY 1996, 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.

ACCOMPLISHMENTS AND PLANS

The systemic change programs address many different levels within the education community and include the AESP. Space Grant, EPSCoR and M-State programs.

The redesign of the AESP format was completed in FY 1995: new training and program delivery strategies were Implemented to include more teacher enhancement emphasis and support of the National Science Foundation systemic change initiatives. Specialists are now directly involved in systemic reform by serving as educational consultants to local schools and school districts, regional educational consortia, state departments of education. and national professional education organizations. Funding in FY 1996 and FY 1997 will continue operation of this p r o m .

In FY 1996, Space Grant plans to initiate a competition for Program Grant consortia to move to Designation status. In addition, 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 effort to bring more members of underrepresented groups into Space Grant management. as well as fellowship awards. A stronger link will be forged between Space Grant and EPSCoR.

FY 1996 marked the second year of the NASA EPSCoR program with funding continuing for the original six awardees. In addition, opportunities were made available to the 13 non-selected states to build upon highly rated research areas from the original proposals. These opportunities were In the form of research grants or participation in existing NASA education programs, and are designed to enhance proposal competitiveness for the next round of selection. An announcement for the next round was issued In spring 1995, with selection of up to eight states scheduled for mid calendar year 1996.

The M-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 8,400 teachers. 150,000 students and thousands of community members.

BASIS OF FY 1997 FUNDING REQUIREMENT

EDUCATION TECHNOLOGY

	FY 1995	FY 1996	FY 1997
	(Thousands of Dollars)		
Learning tools	1,900	2,000	2,000
Demonstrations	3,600	4,200	3,400
Total	5,500	6,200	5,400

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 educational technology program addresses two areas: (1) Development of High-Quality, Mordable Learning Tools and Environments, and (2) Demonstrations of Innovative Technology and Networking Applications. These tools and demonstrations utilize NASA's mission and research results as the content for technology-based programs for educators and students. The educational technology program is also designed to support two of the Administration's four pillars for educational technology. The two pillars supported by our program arc to (1) develop effective and engaging software and on-line learning resources as an integral part of the school curriculum, and (2) provide all teachers the training and support they need to help students learn through computers and the information superhighway. Specific learning tools being developed to support the first pillar include (1) the Astronomy Village, a multimedia program for 9-12 grade science, (2) BioBLAST, a multimedia/network program for high school biology, (3) Tools of Aeronautical research, a high school physical science program, (4) Liftoff to Learning, a series of videotapes featuring onboard sequences videotaped on the Space Shuttle, and (5) Virtual Exploration of Mars, a learning tool based on Virtual Reality technology. NASA Spacelink, an interactive network system for educators, and the videoconference series, On the Cutting Edge, address the second pillar. Additionally, all learning tools are designed to include a teacher training component. The NASA Classroom of the Future continues to be the major component of the educational technology program. The role of the Classroom of the Future (COTF) is to translate NASA technologies and research results into learning tools, demonstrations. and teacher enhancement programs which support standards-based education reform. The Center-based K-12 Internetworking Initiative provides demonstration projects and on-line systems dedicated to bringing real NASA science to teachers and students in the classroom, using examples from NASA's unique missions. The NASA strategy for educational technology has been developed in close consultation and alignment with the NSTC/CET Subcommittee on Research and Development in Education and Training.

MEASURES OF PERFORMANCE

Teacher Resource Center Network	200,000+ users at 69 locations
NASA Spacelink	1,363,000 total sessions: 208,000 sessions averaging 20 minutes/session from 1,600 registered educator accounts
Satellite Videoconferences for Educators	20,000+ teachers annually
Astronomy Village	CD-ROM for science education: high school astronomy program
Classroom of the Future	Major research and development facility
Interactive NOVA	Interactive videodisc for high school Earth science: partnership with private sector; national distribution

ACCOMPLISHMENTS AND PLANS

In FY 1996, the Astronomy Village curriculum package will be disseminated to 12,000 teachers at high schools nationwide. Initial training sessions for teachers are being conducted and will continue in FY 1997. Initial field testing and formative evaluation of the BioBLAST program will be conducted and lessons leamed from teacher experiences will be incorporated into the development. Upon completion in FY 1997, BioBLAST will be disseminated to high school biology teachers nationwide and teacher training will commence. In FY 1996, an evaluation of the Teacher Resource Center Network (TRCN) was conducted: the recommendations from this evaluation wlll be implemented in FY 1996 and will continue into FY 1997. Enhancements to the TRCN will include greater focus on the effective use of technology, particularly internetworking, to ensure a broader group of teachers are reached. A low-cost networking technology will be piloted tested in North Carolina in FY 1996 and transfer of this technology will begin in FY 1996 and continue in FY 1997. Spacelink, NASA's computer information system for educators. will continue to implement enhanced services, especially a series of computer conferences. The Quest K-12 Internet in the Classroom server will continue to provide focused internetworking support, including additional "Sharing NASA" programs such as the Live from Hubble Space Telescope which permits students to make real science observations.

BASIS OF FY 1997 FUNDING REQUIREMENT

EVALUATION

	FY 1995	FY 1996	FY 1997
	(Thousands of Doh)		
Evaluation	500	700	700

PROGRAM GOALS

The goal of the evaluation program is: to provide documented evidence of the degree to which NASA's educational program, with its associated projects and activities. has accomplished its goals: and to develop a systematic strategy for collecting, aggregating, and reporting evaluation indicator data.

STRATEGY FOR ACHIEVING GOALS

NASA has undertaken a comprehensive effort to evaluate the education programs in order to demonstrate the accomplishment of achievable and measurable goals and objectives. Although every NASA education program currently has an evaluation component, a set of indicators, metrics, and evaluation instruments is being developed. intended for Agencywide use, which will be collected on-line in a single, database capable of providing correlation and report generation capability. External education evaluation experts have also been engaged to provide an in-depth survey of various programs and offer recommendations and suggestions about the instruments in development.

MEASURES OF PERFORMANCE

In FY 1995, an evaluation indicators system, with corresponding data collection instruments and a database. was developed. and is expected to be operational in FY 1996 across core NASA education programs. Two major evaluation studies will be implemented with results expected in FY 1996.

ACCOMPLISHMENTS AND PLANS

Evaluation 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 1997 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS — MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1995	FY 1996	FY 1997	page Number
		[Thousands of Dollars)		
Historically black colleges and universities	25,000	28,000	26.800	SAT 7.2-4
Other minority universities	16,800	20,400	19,100	SAT 7.2-11
Graduate student researchers program (Underrepresented minority and disabled focus)	3.400	--	--	
Undergraduate student researchers program..	3,100	--	--	
To	48.300	48.400	45.900	
Distribution of Program Amount by Installation				
Ames Research Center	3,174	3.600	3,700	
Dryden Flight Research Center	97	530	530	
Goddard Space Flight Center	5,450	5,830	5,130	
Jet Propulsion Laboratory	1,148	1.530	1,200	
Johnson Space Center	822	1.130	1,030	
Kennedy Space Center	698	1.030	1,030	
Langley Research Center	2,217	2,530	1,880	
Lewis Research Center	1,907	1.530	1,030	
Marshall Space Flight Center	1,260	1.590	1,300	
Stennis Space Center	922	1,030	1,000	
Headquarte	30,605	28,070	28,070	
To	48.300	48.400	45.900	

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

PROGRAM GOAL

NASA has made a major commitment to being a leader in strengthening the research infrastructure capabilities of minority universities and thereby, enhancing their opportunity to compete for "mainstream" federal funding. The goal of the Minority University Research and Education program is to strengthen the NASA-related research capabilities of Historically Black Colleges and Universities (HBCU's) and Other Minority Universities (OMU's), primarily Hispanic-Serving Institutions (HSI's) and Tribal Colleges. Through sufficient research infrastructure-building support and exposure to the NASA peer review process. these institutions will be able to build sustainable systemic programs that use NASA-related research to enhance research and education outcomes, and to substantially contribute to the development of a 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. Congress and the Executive Branch have established a clear record of commitment to increasing the involvement of minority institutions in federally-sponsored programs. Several of the Administration's national educational goals relate to strengthening the capacity of HBCUs and OMU's to provide excellence in education so that they may continue to play a vital role by adding to the diversity and caliber of the Nation's higher education system. The NASA Minority University Research and Education program seeks to form alliances among minority institutions. majority research institutions. state and local governments, elementary and secondaxy schools, industry and other Federal Research and Development programs in order to contribute toward these goals.

The Minority University Research and Education program pursues these alliances through the aggressive implementation of research initiatives for HBCUs and OMU's and by supporting undergraduate and graduate student incentive programs, primarily at these institutions. The NASA Program Offices and Installations *are* actively involved in this strategy by providing financial and technical assistance. This assistance includes ensuring sufficient research support and exposure to the NASA peer review process so that minority institutions (MI's) and their faculty and students are able to demonstrate creativity. productivity, and future promise in the transition toward achieving competitive awards in the Agency's "mainstream" research and employment processes. There is close collaboration with the NASA Education programs to ensure that MI's and their elementary and secondary school partners. especially those with predominant enrollments of socially and economically disadvantaged and disabled 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 HBCU's and OMU's. thereby increasing the scientific and technological contributions from these institutions, and increasing the pool of socially and economically disadvantaged and disabled students, historically underrepresented in the Agency's research and education programs, and 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 stimulate use of the Internet as an integral part of minority universities' interdisciplinary research and education programs.
- Principal Investigator Awards - to identify outstanding and promising faculty early in their academic careers who have had limited NASA research grant experience and are capable of contributing to the Agency's research objectives.
- Math and Science Awards - to contribute to the Nation's mathematics, science and technology goals by supporting graduate and undergraduate students in NASA-related fields of study, and 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 socially and economically disadvantaged and disabled students while contributing to the diversity in the pool of Agency researchers.

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 1995, the NASA Program Offices collaborated with the Office of Equal Opportunity Programs (OEOP) to solicit and competitively fund research activities at minority colleges and universities. Their contribution to OEOP's programs totaled $20.8 million in FY 1995. This level of funding is expected to remain constant through FY 1997.

To encourage the development of talent at the undergraduate and graduate levels, NASA will continue to support undergraduate and graduate level students pursuing degrees in science or engineering. All awards made through the minority university program have as a selection criteria the development of human resources through research-based experiences from which NASA and the aerospace industry can draw. Students selected under these awards 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. Consistent with Congressional direction to 'develop and increase Ph.D. graduate fellowships at HBCU's and HSI's," the focus of these awards was shifted in FY 1996 away from the individually-based Graduate and Undergraduate Student Researchers Programs to institution-based programs at those institutions with proven track records of producing graduates in NASA-related fields.

BASIS OF FY 1997 BUDGET REQUIREMENT

	FY 1995	FY 1996	FY 1997
		[Thousands of Dollars]	
Historically black colleges and universities	25,000	28,000	26,800

PROGRAM GOAL

The goal of NASA's Historically Black Colleges and Universities (HBCU) program is to strengthen the capacity of HBCU's to provide quality education: and to increase opportunities for HBCU's, their faculty, and students to participate in and benefit from NASA's research and education programs.

STRATEGY FOR ACHIEVING GOALS

HBCU's 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 establlshed a Federal program "...to strengthen and expand the capacity of HBCU's to provide quality education." Executive Orders issued by Presidents Ronald Reagan and George Bush strengthened this program. NASA's current initiatives for HBCU's 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 HBCU's to participate in and benefit from federal programs to achieve an Increase in the participation by HBCU's in federal p r o m . " Executive Order 12928, signed February 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 were established during FY 1991 by the Headquarters Office of Space Science and Appllcatlons: the Office of Aeronautics; the Office of Space Flight; and the Office of Equal Opportunity Programs. The goal of the HBCU Research Center Awards 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 HBCU faculty and students in the Agency's research. Seven Research Centers were selected In 1991 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 HBCUs

existing undergraduate and graduate research programs: management and staffing of the research center; the university's long-term institutional strategic commitment in the core research area; and university. government agency. and industry partnerships.

The following institutions were selected as the initial HBCU Research Centers:

University	Research Focus
Clark Atlanta University	High Performance Polymers and Ceramics (HiPPAC) Center
Fisk University	Center for Photonic Materials and Devices
Florida A&M University	Center for Nonlinear and Nonequilibrium Aeroscience
Hampton University	Center for Optical Physics
Howard University	Center for the Study of Terrestrial and Extraterrestrial Atmospheres
North Carolina A&T State University	Center for Aerospace Research
Tuskegee University	Center for Food Production. Processing and Waste Management for Controlled Ecological Life Support Systems (CELSS)

In addition, four new HBCU Research Centers were selected in FY 1995 to receive 5-year cooperative agreement awards. Selections were based on the same criteria described above. with additional emphasis on the strength of the educational commitment of the institution and its ability to produce high-quality graduates in NASA-related fields of study. The new institutions are:

University	Research Focug
Alabama A&M University	Center for Hydrology, Soil Climatology and Remote Sensing
Morehouse School of Medicine	Space Medicine and Life Sciences Research Center
Prairie View A&M University	Center for Applied Radiation Research
Tennessee State University	Center for Automated Space Science

NASA's Institutional Research Awards (IRA) was expanded to include HBCUs during FY 1995. The IRA's targets HBCUs who do not receive significant NASA research funding and who offer graduate degree programs in engineering or science. The objectives of the IRA's *are:* to strengthen and improve core research areas of significance to the NASA mission: to increase the number of socially and economically and disabled students (hereafterreferred to as disadvantaged students) who are U.S. citizens conducting space research and working in NASA-related disciplines: and to 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, disadvantaged U.S. citizens who are undergraduate and graduate student researchers. and technology transfer to the market place and to minority communities. The 1995 IRA solicitation called for research proposals that achieve routine full Internet usage at HBCUs conducting NASA-related research and education. The following HBCU's were selected to receive 5-year

cooperative agreements: Morgan State University. Elizabeth City State University, South Carolina State University, Tennessee State University. and Prairie View A&M University.

Principal Investigator Awards identify outstanding and promising engineering, physical and life science tenured and tenure-track faculty at minority institutions 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, and future promise in the transition toward achieving competitive awards in the Agency's mainstream research processes. In FY 1996. these awards were expanded to include greater support for graduate and undergraduate students to become involved in the research projects.

In FY 1995, the NASA Program Offices contributed $12.8 million in support of research activities conducted at HBCU's as described above. This funding is expected to remain the same in FY 1996 and FY 1997.

The **HBCU Mathematics and Science Awards** focus on strengthening the capacity of HBCUs to provide excellence in mathematics, science. engineering and technology (MSET) training while increasing the participation and achievement of disadvantaged students in MSET fields at all levels of education.

The **Undergraduate Scholars Awards** identify high school senior and continuing first-year students majoring in science, engineering. mathematics or computer science and awards them scholarships through HBCUs with proven records of recruiting, retaining and graduating disadvantaged students in these fields. These awards support approximately 300 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 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. It is expected that these students will form part of the pool from which NASA selects graduate researchers.

The **Graduate Researchers Awards** develop and increase Ph.D. graduate fellowship programs at HBCU's and HSI's offering Ph.D.s in NASA-related discipline areas. In FY 1995, a panel of outside experts was convened to examine this program and recommend changes. Based on their final report, MURED significantly restructured the program in FY 1996. Changes include increasing recruitment of Mastem-level candidates, aggressively identifying and working with minority institutions offering graduate degrees in NASA-related disciplines, limiting the number of institutions allowed to participate, and focusing on institution-based awards managed by the NASA Installations. This strategy allows for better tracking of students and the development of stronger graduate programs at the Minority Institutions. NASA also continues to support graduate students through several national programs. One, the American Society for Engineering Education (ASEE) Helen T. Carr Fellowship program, provides fellowships for faculty at HBCU's to pursue 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 6

years of support to students pursuing Ph.D.s in the physical sciences. Support for another program, the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM). will be expanded to target more undergraduate students graduating from minority institutions where NASA has a substantial investment in research and training activities. Currently, the majority of students in these programs attend majority research institutions.

Desired outcomes for recipients of the undergraduate scholars and graduate researchers awards include employment with NASA or aerospace industries. as science and engineering faculty researchers, or as mathematics and science pre-college teachers: entrepreneurs: and general scientific literacy.

NASA has established Technical Review Committees to provide technical guidance and on-site reviews to recipients of Institutional Research Awards and Research Center awards. 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) 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 JPL.

NASA Headquarters Program Ofnces. 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 HBCU's spend time on-site at the Installations and 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 HBCU's. During FY 1995, 123 faculty-level investigators were involved in NASA-related research work at the seven initial HBCU Research Centers. During this period, the HBCU Research Centers involved in their research work 104 graduate and 152 undergraduate U.S. citizen students, produced 162 refereed papers or book chapters, and gave 214 presentations at research conferences or seminars. Building on their NASA/MURED funding. the HBCU Research Centers secured a total of $7.0 million in 1995 research funding from other sources as compared to the $10.8 million Invested by MURED and the Program Ofnces in FY 1995. Service on NASA peer review and advisory panels is a key indicator of integration into the mainstream of NASA research: in FY 1995, eight incidences of such service were reported by the HBCU Research Centers.

During FY 1995, 134 faculty researchers were involved in individual principal investigator research projects at HBCUs. Similar data for these individual principal investigator awards is being compiled, but is not yet available. In FY's 1996 and 1997, the productivity represented by these indicators is expected to increase as the existing HBCU Research Centers and IRA's reach maturity.

The ultimate goal of the Equal Opportunity Programs' graduate researchers and undergraduate scholars awards is to increase the pool of researchers in the NASA research community. Progress towards achieving this goal is monitored through assessing the

numbers of U.S. citizen students involved in NASA-related research and studies through OEOP support. While the total numbers of such students is projected to remain roughly constant through FY 1997. funding will continue to shift to ensure the inclusion of students at minority universities. Ultimate success is measured by the retention rate, number of students entering graduate programs, and number of students employed in scientific and technological fields.

Pre-college students are involved mainly through faculty, student and teacher preparation programs carried out by HBCUs. In FY 1995. NASA outreach programs at 17 HBCUs involved 6,700 students in mathematics, science. engineering, and technology enhancement activities. These numbers increased significantly over FY 1994. as the Mathematics. Science and Technology Preparation and Curriculum Enhancement Awards (MASTAP) and the Precollege Awards for Excellence (PACE) awards were initiated at HBCU's in FY 1995. OEOP plans four new PACE awards at HBCUs, both in FY's 1996 and 1997. These awards *are* described in detail on the following page.

ACCOMPLISHMENTS AND PLANS

In FY 1995, NASA provided targeted support to 43 out of the 106 existing HBCUs.

NASA provided the fourth year of funding for seven HBCU Research Centers during FY 1995. *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 1996, these seven Research Centers will be sustained for a fifth year. The opportunity to compete for another 5 years of reduced funding will be made available to these HBCUs after a comprehensive review of the initial 5-year awards is completed. Four new Research Centers were selected in FY 1995. and they will undergo similar reviews to receive renewal funding during the planned 5 years of their awards.

During FY 1995. the Institutional Research Awards (IRA) program invited the participation of HBCUs. and five institutions were selected through a competitive process to receive awards. The focus of the FY 1995 awards was on establishing HBCU Network Resources and Training Sites (NRTS). These sites will be responsible for stimulating the use of the Internet via computer networks 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 at least five other educational institutions in their region, and to serve as user resource centers and network trainers for the faculty, teachers and students in their region. No new IRA selections are planned during FY 1996 or FY 1997. However, these five IRA's will be sustained during that time.

The awards to individual PI's at HBCUs increased to 134 awards between FY 1995 and FY 1996. and will remain at that level in FY 1997. The average award is $75.000. 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 JPL technical personnel. Following the merit review. selections are made by NASA Headquarters Program Offices and FAR recipients *are* awarded 3-year research grants. During FY 1996, six third-year and two second-year HBCU FAR awards will be continued,

and up to 10 new FAR recipients will be selected. During FY 1997, the six expiring FAR awards will be replaced through a competitive process, and the second and third year awards renewed.

In FY 1995, 177 students were supported through graduate researchers awards; 33 of those attended HBCU's. This included support for two new programs, at Florida A&M and North Carolina A&T Universities, supporting 30 graduate students in engineering. These numbers are expected to remain constant through FY 1997.

In FY 1995.300 students were supported through undergraduate scholars awards at HBCU's. The pipeline of undergraduate students majoring in the physical and life sciences and engineering coming from this program is expected to substantially and positively impact NASA's and the aerospace industry's human resources needs. These students are also being targeted for graduate level studies and research careers in the fields of science and engineering. The recipients of undergraduate awards are expected to feed into the graduate researchers programs. especially considering the relationships the students develop with the NASA Installations and Jet Propulsion Laboratory as a result of being an undergraduate scholar. Each year the graduating class will be replaced by new selections. thereby keeping the total number of participants fairly constant over the next several years.

During FY 1995. NASA, in collaboration with the National Science Foundation. supported two HBCU's selected as Model Institutions of Excellence (MIE's). The primary goal of the MIE awards is to strengthen the science, engineering and mathematics baccalaureate degree-producing capacity at minority institutions. Spelman College and Bowie State University received 5-year cooperative agreement awards.

In support of the national mathematics and science education goals, NASA funds educational programs to support the preparation, persistence and participation of disadvantaged students 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 Mathematics. Science and Technology Preparation and Curriculum Enhancement Awards (MASTAP) and the Precollege Awards for Excellence in Mathematics. Science, Engineering and Technology (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 teachers well-prepared to teach science and mathematics to disadvantaged students using content from NASA's education programs. MASTAP is designed to expand the number and strengthen the technical skills and knowledge of mathematics, science and technology pre-service teachers at HBCU's who become state-certified to teach in middle and high schools that have substantial enrollments of disadvantaged students: and to improve mathematics and science literacy among pre-service and in-service teachers and middle and high school students. In FY 1995. HBCUs were able to submit proposals for the first time in response to NASA's program notice, and four institutions were selected to receive 3-year grant awards through the competitive peer review selection process. NASA will sustain these awards through FY 1997 but does not plan any new awards during FY 1996 and FY 1997.

The PACE/MSET awards were initiated in FY 1995. The purpose of these awards 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 disadvantaged students in college preparatory mathematics, science and technology courses in public middle and high

schools with substantial enrollments of minorities. During FY 1995, NASA competitively selected five awards at HBCU's and continued to fund other ongoing efforts for a total of 19 pre-college projects. In FY 1996, NASA will use the PACE/MSET competitive review process to select four new awards, bringing the number of projects at HBCU's to 23. Similar selections are planned for FY 1997.

BASIS OF FY 1997 BUDGET REQUIREMENT

	FY 1995	FY 1996	FY 1997
		(Thousands of Dollars)	
Other minority universities	16,800	20.400	19,100

PROGRAM *GOAL*

The goal of NASA's Other Minority Universities (OMU) program is to increase the opportunities for Hispanic-Senring Institutions (HSI's), Mbal Colleges and educational organizations serving substantial numbers of 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...build a closer relationship with institutions sewing significant numbers of minorities.." To provide greater emphasis on this congressional mandate, NASA established the OMU Program in 1991. Since that time, Presidential Executive Orders and congressional reports have provided additional guidance 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. 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 responded to the early Congressional and Executive Branch direction by formulating a 5-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. The plan addressed all institutions with significant minority populations other than Historically Black Colleges and Universities (HBCUs). The OMU plan was expanded in FY 1993. when the NASA Administrator signed a plan to strengthen the Agency's relationships with Hispanic-Serving Institutions (HSI's). The direction received from the Congress and Executive Branch is reflected in the current program plan for OMU's.

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 HBCUs 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. Until 1991, unsolicited proposals were the primary mechanisms used to fund mathematics and science awards. In FY 1994, the first minority university program. the Mathematics, Science and Technology Teacher Preparation and Curriculum Enhancement Awards (MASTAP) program competitive announcement of opportunity was issued for response by the OMU's. The individual Principal Investigator (PI) awards were established in FY 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 OMU's to NASA research.

To enhance and build research capability in a core research area, NASA issued the first announcement of opportunity for IRA's to OMU's in FY 1994. The IRA's target OMU's who do not receive significant NASA research funding and who offer graduate degree programs in engineering or science. The specific objectives of the IRA's are: to strengthen and improve core research areas of significance to the NASA mission: to increase the number of socially and economically and disabled students (hereafter referred to as disadvantaged students) who are U.S. citizens conducting space research and working in NASA-related disciplines: and to 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, disadvantaged U.S. citizens who are undergraduate and graduate student researchers, and technology transfer to the market place and to minority communities.

The final strategy in NASA's plan, to strengthen the research capability at OMU's. was implemented in FY 1995 when the Agency selected three OMU Research Center Awards through a competitive process. The institutions selected are:

University	Research Focus
University of New Mexico	Center for Autonomous Control Engineering
University of Puerto Rico, Mayaguez Campus	Tropical Center for Earth and Space Studies
University of Texas El Paso	Pan American Center for Earth and Environmental Studies

In FY 1995. the NASA Program Offices contributed $8.0 million in support of these research activities conducted at OMU's. This funding is expected to remain level in FY's 1996 and 1997.

The **OMU Mathematics and Science Awards** focus on strengthening the capacity of OMU's to provide excellence in mathematics. science, engineering and technology (MSET) training while increasing the participation and achievement of disadvantaged students in MSET fields at all levels of education. Among these programs is the Information Infrastructure Technology and Applications (IITA) project, which focuses on developing curriculum enhancement products for K-12 education, building on a core program of K-12 education programs at NASA Centers, and expanding to a broad outreach program to educational product developers in academia and the private sector.

The **Undergraduate Scholars Awards** identify high school senior and continuing first-year students majoring in science, engineering, mathematics or computer science and awards them scholarships through OMU's with proven records of recruiting, retaining and graduating disadvantaged students in these fields. These awards support approximately 300 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 JPL 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. It is expected that these students will form part of the pool from which NASA will select graduate researchers.

The **Graduate Researchers Awards** program develops and increases Ph.D. graduate fellowship programs at HBCUs and HSI's offering Ph.D.s in NASA-related discipline areas. In FY 1995, a panel of outside experts was convened to examine this program and recommend changes. Based on their final report, MURED significantly restructured the awards in FY 1996. Changes include increasing recruitment of Masters-level candidates, aggressively identifying and working with minority institutions offering graduate degrees in NASA-related disciplines, limiting the number of institutions allowed to participate. and focusing on institution-based programs managed by the NASA Installations. This strategy allows for better tracking of students and the development of stronger graduate programs at the Minority Institutions. NASA also continues to support graduate students through several national programs. One program, the National Physical Science Consortium (NPSC) Fellowship, provides up to 6 years of support to students pursuing Ph.D.s in the physical sciences. Support for another program, the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM), will be expanded to target more undergraduate students graduating from minority institutions where NASA has a substantial investment in research and training activities. Currently, the majority of students in these programs attend majority research institutions.

Desired outcomes for recipients of the undergraduate scholar and graduate researchers awards include employment with NASA or aerospace industries. as science and engineering faculty researchers, or as mathematics and science pre-college teachers: entrepreneurs: and general scientific literacy.

NASA has established Technical Review Committees to provide technical guidance and on-site reviews to recipients of Institutional

Research Awards and Research Center award recipients in order to help them achieve their goals. NASA promotes collaboration between its HBCU-funded programs, the Installations and the 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) 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 JPL.

NASA Headquarters Program Offices, NASA Installations and the Jet Propulsion Laboratory support the OMU 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 OMU's spend time on-site at the Installations and JPL throughout the year.

MEASURES OF PERFORMANCE

The first grant year of the IRA awards was completed in FY 1995. During this period, 44 faculty-level researchers. along with 19 graduate and 29 undergraduate U.S. citizens, were involved in NASA-related research with the six IRA's. Also in FY 1995. 111 faculty researchers were involved in individual principal investigator projects at OMU's. Information on publications and leveraged funding at these institutions is being tracked and will be reported at the end of the second grant year. In addition. information on student and faculty participation rates at the newly selected OMU Research Centers will be available at the end of grants' first year midway through FY 1996.

The ultimate goal of the Equal Opportunity Programs' graduate researchers and undergraduate scholars awards is to increase the pool of researchers in the NASA research community. Progress towards achieving this goal is monitored through assessing the numbers of U.S. citizen students involved in NASA-related research and studies through OEOP support. While the total numbers of such students is projected to remain roughly constant through FY 1997, funding will continue to shift to ensure the inclusion of students at minority universities. Ultimate success is measured by the retention rate. number of students entering graduate programs, and number of students employed in scientific and technological fields.

Pre-college students are involved mainly through faculty. student and teacher preparation programs carried out at OMU's. In FY 1995, NASA supported outreach programs at 23 OMU's (including eight Hispanic-Sewing Institutions and three Tribal Colleges) and 10 educational organizations. These programs involved 32,886 students in mathematics, science, engineering, and technology enhancement activities. These were significant increases over FY 1994 as MASTAP was expanded and PACE/MSET was initiated. These numbers are expected to increase further as four new PACE awards are made during FY 1996 and FY 1997.

CCOMPLISHMENTS PLANS

In FY 1995, NASA initiated Research Center Awards for OMU's: three institutions were competitively selected to receive awards. NASA will sustain these three Research Centers for a second year in FY 1996 and a third year in FY 1997.

During FY 1994. six HSI's successfully competed to receive Institutional Research Awards (IRA's). 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 San Antonio

The 1995 IRA solicitation called for research proposals that achieve routine full Internet usage at OMU's conducting NASA-related research and education. The City College of New York and the University of Texas at El Paso were selected in FY 1995 to receive 5-year cooperative agreements. In FY 1996 NASA will sustain these eight awards. In FY 1997. NASA will sustain six fourth-year and two third-year IRA awards to HSI's. No new selections are planned due to budget constraints.

The awards to individual PI's at OMU's increased slightly in FY 1995 to 111 awards, and will remain level through FY 1997. The average award is $75.000. 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 JPL technical personnel. Following the merit review, selections are made by NASA Headquarters Program Offices and FAR recipients are awarded 3-year research grants. During FY 1996. 15 third-year and one second-year OMU FAR awards will be continued, and up to 10 new FAR recipients will be selected. During FY 1997. the fifteen expiring FAR awards will be replaced through a competitive process. and the second and third year awards renewed.

In FY 1995. 177 students were supported through graduate researchers awards: 20 of those attended OMU's. These numbers are expected to remain constant through FY 1997.

In FY 1995,172 students were supported through undergraduate scholars awards at OMU's. The pipeline of undergraduate students majoring in the physical and life sciences and engineering coming from these awards is expected to substantially and positively impact NASA's and the aerospace industry's human resources needs. Even more important, these students are being targeted for graduate level studies and research careers in the fields of science and engineering. The recipients of undergraduate awards will feed into the graduate researchers programs, especially considering the relationships the students develop with the NASA Installations and JPL as a result of being an undergraduate scholar. Each year the graduating class will be replaced by new selections, thereby keeping the total number of participants fairly constant Over the next several years.

In support of the national mathematics and science education goals, NASA funds educational programs to support the preparation. persistence and participation of disadvantaged students 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 Mathematics. Science and Technology Preparation and Curriculum Enhancement Awards (MASTAP) and the Precollege Awards for Excellence in Mathematics, Science. Engineering and Technology (PACE/MSET).

The primary objective of MASTAP is to support institutions of higher education to increase the number and quality of teachers well-prepared to teach science and mathematics to disadvantaged students using content from NASA's education programs. MASTAP is designed to expand the number and strengthen the technical skills and knowledge of mathematics, science and technology pre-service teachers at OMU's who become state-certified to teach in middle and high schools that have substantial enrollments of disadvantaged students: and to improve mathematics and science literacy among pre-service and in-service teachers and middle and high school students. In FY 1995, NASA sustained three second-year awards and competitively selected three additional awards at OMU's. In FY 1996. NASA will sustain these six awards at $200,000 each but will not make any new selections. In FY 1997. the three expiring awards will be replaced and the 3 third-year awards renewed.

The PACE/MSET awards were initiated in FY 1995. The purpose of these awards 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 disadvantaged students in college preparatory mathematics. science and technology courses in public middle and high schools with substantial enrollments of minorities. During FY 1995, NASA competitively selected three awards at OMU's for $100.000 each and continued to fund other ongoing efforts for a total of 27 pre-college projects. In FY 1996, NASA will use the PACE competitive review process to increase the number of projects at OMU's to 31. and in FY 1997 to 35.