HUMAN SPACE FLIGHT
FISCAL YEAR 1998 ESTIMATES
BUDGET SUMMARY

OFFICE OF SPACE FLIGHT
SPACE SHUTTLE

SUMMARY OF RESOURCES REQUIREMENTS (Thousands of Dollars)

Space Shuttle	FY 1996	FY 1997	FY 1998
Safety and performance upgrades	658,400	636,000	483.400
Shuttle operations	2,485,400	2,514,900	2,494,400
Total	3,143,800	3,150,900	2,977,800

Distribution of Program Amount by Installation	FY 1996	FY 1997	FY 1998
Johnson Space Center	1,006,300	976,300	1,061,100
Kennedy Space Center	795,800	777,600	753,800
Marshall Space Flight Center	1,265,900	1,330,100	1,101,900
Stennis Space Center	51,700	40,500	33,900
Dryden Flight Research Center	5,600	5,400	5,900
Goddard Space Flight Center	100	--	--
Jet Propulsion Laboratory	200	--	--
Headquarters	18,200	21,000	21,200
Total	3,143,800	3,150,900	2,977,800

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 were flown 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.

The Space Shuttle Program, on average, is safely flying more flights at less cost than ever before in the history of the program. The restructuring activities of the past five years have resulted in net dollar savings of 27% by FY 1997, equating to 25% less workforce. Reliability has improved by decreasing probability of catastrophic loss of the vehicle on ascent from 1 in 78 launches to 1 in 248, as estimated in the Probabilistic Risk Assessment report (SAIC Corporation, 1995). In addition, after 80 successful missions, a significant reduction in operational requirements is continuing. For example, in 1989, 1.6 million hours were required to process a Space Shuttle mission; today it is one-third of that number. Consolidation of contracts into a single prime contract was accomplished with the award of the Space Flight Operations Contract on October 1, 1996. This transition is scheduled to be completed in the next two years. The Space Shuttle continues to prove itself as the most versatile vehicle ever built, as demonstrated by performing rendezvous missions with the Russian Space Station Mir; advancing life sciences and technology through long-duration Spacelab and Spacehab missions; repairing and servicing the Hubble Space Telescope; enabling discovery of new astronomical events; rescuing and retrieving spacecraft; and preparing for the historic assembly of the International Space Station. This budget request further positions the Space Shuttle program to meet the challenges of space travel in the next century with an increased degree of safety and a decreased need for public funding.

PROGRAM GOALS

The program goals of the Space Shuttle program are in priority order: 1) fly safely; 2) meet the flight manifest; 3) improve supportability; and, 4) reduce costs. These goals are reflected in our decisions regarding flight requirements, budget reductions and programmatic changes. The flight rate for FY 1996 was eight successful flights. The FY 1997 and FY 1998 flight rate is seven flights per year. For FY 1999 and FY 2000, the flight rate is eight per year due to the addition of another Mir mission to the manifest and the new Shuttle Radar Topography Mission (SRTM), a joint DOD/NASA mission. This manifest supports the nation's science and technology objectives through scheduled Spacelab, Spacehab and other science missions, cooperative missions to the Russian space station Mir, and assembly of the International Space Station.

In addition to flying safely, restructuring the program, and conducting the single prime contract consolidation, we are continuing our emphasis on the Safety and Performance Upgrades program. This program includes a selected set of projects designed to improve the Space Shuttle safety and to improve performance by 13,000 pounds, allowing the Orbiter to achieve the orbital inclination and altitude of the International Space Station and support its assembly beginning in FY 1998. This budget also includes additional upgrades to allow the program to continue to fly safely and meet customer requirements in the most efficient manner practicable well into the next century. The program has initiated a supportability upgrade program should the Shuttle be required to operate past 2012. These upgrades address all elements of the Space Shuttle program and are managed through an approval process ensuring that new projects are evaluated, approved and initiated on a priority basis. The process also ensures that existing projects are meeting established cost and schedule goals.

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 provide for the safe, continuous, and affordable operations of the Space Shuttle system, at a minimum, throughout the Space Station era (2012).

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 Space Flight Operations Contract (SFOC) represents a key element of this strategy.

SAFETY AND PERFORMANCE UPGRADES

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
Orbiter improvements	**271,400**	**169,900**	**137,300**
Multifunction electronic display system	40,600	32,400	15,300
Simplified aid for EVA rescue	7,100	7,800	--
Global positioning system	9,200	9,600	1,300
Other orbiter improvements	214,500	120,100	120,700
[Supportability Upgrades] [included above]	--	[50,000]	[50,000]
Propulsion upgrades	**272,000**	**342,800**	**247,000**
Space shuttle main engine upgrades	234,100	324,500	231,200
(Alternate Turbopump program)	(97,000)	(95,400)	(96,200)
(Other main engine upgrades)	(137,100)	(229,100)	(135,000)
Solid rocket booster improvements	**7,200**	**800**	**6,600**
Super lightweight tank	**30,700**	**17,500**	**9,200**
Flight operations & launch site equipment upgrades	**97,600**	**115,000**	**92,300**
Flight operations upgrades	73,400	89,000	51,500
Launch site equipment upgrades	24,200	26,000	40,800
[Supportability Upgrades]	--	[20,000]	[45,000]
Construction of facilities	**17,400**	**8,300**	**6,800**
Modernize fire system, pads A and B	(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)	--
MSFC/MAF 480V Electrical Distribution System Phase II	--	--	(2,800)
KSC Pad A PRC Wall and Ceiling Integrity/Safety	--	--	(2,200)
KSC Pad A Surface and Slope Restoration	--	--	(1,800)
Total	**658,400**	**636,000**	**483,400**

GENERAL

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, and also the effect these projects have on the operation of the Space Shuttle Orbiter. Success depends on developing these projects and getting them implemented to help insure the Space Shuttle's safe operation, and improve the reliability of the supporting elements.

The FY 1998 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. This budget also includes Supportability upgrades to develop more advanced systems which will combat obsolescence of vehicle and ground systems in order to maintain the program's viability into the next century. Vendor loss of aging components, high failure rates of older components, high repair costs of Shuttle-specific devices, and negative environmental impacts of some out-dated technology are areas to be addressed. The Supportability Upgrades will be studied and initiated in FY 1997. As stated in the FY 1997 Initial Operating Plan letter, dated December 20, 1996; $107 million will be applied to these upgrades from available reserves and uncosted obligations. In FY 1998, our request includes $95M to continue those upgrades increasing reliability and maintainability of the Shuttle systems and also to continue studies to assess feasibility of implementing more state-of-the-art technologies into the system. This did not increase the previously planned FY 1998 funding level for the Space Shuttle program, The program has identified internal offsets, largely in the form of program reserves and improved management of uncosted carryover balances.

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 Boeing North American (formerly, the Rockwell International Space Division) in two major locations in FY 1998: the Downey, California facility provides engineering, manufacturing and testing; and the Palmdale, California operation provides Orbiter Maintenance Down Period (OMDP) support discussed below. 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 the Boeing North American 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 (SSC), 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 Marshall Space Flight Center (MSFC). The Alternate Turbopump project is also managed by the MSFC under contract with Pratt Whitney of West

Palm Beach, FL. Development of the Super Lightweight Tank 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 flight operations facilities at Johnson Space Center (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 Space Shuttle training aircraft, the T-38 aircraft and the Space Shuttle Carrier Aircraft (SCA). The major launch site operational 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 support the Space Shuttle Operations.

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 funding a series of safety, performance, and supportability Shuttle upgrades 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 II Space Shuttle Main Engine (SSME) in late CY 1997.

The major safety and performance upgrades and their initial flight dates are listed on the following chart on the next page.

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/implementing these projects and 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.

Performance Milestone	**Plan**	**Actual/Revised**	**Description/Status**
Initial SAFER Flight Demonstration	4th Qtr FY 1996	2nd Qtr FY 1996	Demonstrate on STS-64 flight. The unit was utilized for the first time on the STS-76/Mir-03 flight.
Conduct Preliminary Design Review (PDR) for SAFER	2nd Qtr FY 1996	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	1st Qtr FY 1997	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 1997.

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.

Performance Milestone	Plan	Revised	Description/Status
Complete MEDS Qualification Testing	1st Qtr FY 1996	2nd Qtr FY 1997	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. Delay was due to change in glass supplier.
MEDS Initial Operational Capability (IOC)	4th Qtr FY 1998	2nd Qtr FY 1999	First flight of a MEDS equipped Orbiter. Revised due to glass supplier change.

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 Shuttle's system is FY 1999.

Performance Milestone	Plan	Revised	Description/Status
Complete GPS Preliminary Design Review (PDR)	4th Qtr FY 1996	2nd Qtr FY 1997	Completion of System Requirements Review will allow design drawings to proceed toward CDR. Delay is due to a change in the procurement from the originally-planned, single-string GPS, to the GPS Inertial Navigation System (INS), which will have broader applications (e.g., RLV, ISS) than the previous version.
Complete GPS System Requirements Review	4th Qtr FY 1996	2nd Qtr FY 1997	Completion of CDR will allow drawings to be released for production to proceed. Delay is due to the change from the original, single-string GPS, to the GPS Inertial Navigation System..
Complete GPS operational capability	2nd Qtr FY 1999	--	Initial operation of GPS without TACAN system.

Orbital Maintenance Down Periods

Performance Milestone	**Plan**	**Actual/Revised**	**Description/Status**
Complete Discovery (OV-103) OMDP	1st Qtr FY 1997	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	4th Qtr FY 1996	Conduct routine maintenance; prepare Endeavour for the International Space Station operations; outfit with external airlock. Endeavour is presently at Palmdale.

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.

Performance Milestone	Plan	Actual/Revised	Description/Status
Aluminum-Lithium Test Article (ALTA) testing complete	4th Qtr FY 1996	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	3rd 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. Revised due to welding proof tests.
Deliver first SLWT to KSC for flight	4th Qtr FY 1997	--	Final assembly and checkout will be conducted at the Michoud Assembly Facility (MAF) in New Orleans, Louisiana

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

Performance Milestone	Plan	Actual/Revised	Description/Status
High Pressure Fuel Pump Critical Design Review (CDR)	3rd Qtr FY 1996	2nd Qtr FY 1997	Completion of CDR will allow production to proceed for implementation of the ATP high pressure fuel pump into the Block II Engine upgrade. The delay is the result of several technical problems experienced in the fuel pump design, discovered during testing, which are being modified and retested.
First flight of the Block II engine	4th Qtr FY 1997	1st Qtr FY 1998	The high pressure fuel turbopump will be combined with the large throat main combustion chamber (LTMCC). Revised due to testing delays resulting from technical design difficulties.

Flight Operations and Launch Site Equipment Upgrades - Upgrades to the Mission Control Center will occur during FY 1996-98 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 Processing System in the Launch Site Equipment budget at KSC will increase reliability and reduce obsolescence.

Performance Milestone	Plan	Actual/Revised	Description/Status
Begin ascent/entry mission support from new MCC	1st Qtr FY 1996	2nd Qtr FY 1996	Complete entire mission profile with the new MCC during STS-73 mission
Replacement of displays and controls	3rd Qtr FY 1996	3rd Qtr FY 1996	Installation of new state-of-the-art system will allow more efficient operations
New MCC front end implementation and equipment replacement.	4th Qtr FY 1996	4th Qtr FY 1996	Implementation of new commercial off-the-shelf (COTS) system will allow removal of obsolete custom built equipment and consoles with significant reduction in life cycle costs.
Implementation of new MCC command server system	4th Qtr FY 1997	--	Removal of command functions from the mainframe Mission Operations Computer (MOC) is a major step which will significantly reduce command and control life cycle costs.
Complete development of the new Consolidated Planning System (CPS) and phase-out of Flight Planning System	4th Qtr FY 1996	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 Space Shuttle and Station operations.

Launch Site Equipment Upgrades

Performance Milestone	Plan	Actual/Revised	Description/Status
Deliver first two Portable Purge Units	4th Qtr FY 1996	3rd Qtr FY 1997	First units delivered and tested by user. Revised due to delay in award of contract.

Construction of Facilities

Performance Milestone	Plan	Actual/Revised	Description/Status
Replace Fire Protection Pumps and Piping at LC-39/A&B	3rd Qtr FY 1996 (Phase I) 3rd Qtr FY 1997 (Phase II)	3rd Qtr FY 1996 (Phase I) 4th Qtr FY 1997 (Phase II)	Pumps are currently inadequate to provide spray coverage during an emergency. Phase I - Pad A Complete. Phase II - -Pad B work to be accomplished during down time of launch pad - January 97 to August
Replace Component Refurbishment and Chemical Analysis Facility at KSC	2nd Qtr FY 1996 (Phase I) 2nd Qtr FY 1996 (Phase II Start) 2nd Qtr FY 1997 (Phase II Complete)	1st Qtr FY 1997 (Phase I) 4th Qtr FY 1996 (Phase II Start) 4th Qtr FY 1997 (Phase II Complete)	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 - Complete activation of component refurbishment building. Delay due to extended negotiation with the activation contractor. Phase II Start - Begin construction of chemical analysis facility. Revised plan due to delay in FY 1996 appropriation bill. Phase II Complete - Completion of construction.

SSME Processing Facility	Begin Construction 4th Qtr FY 1996 Complete Construction 2nd Qtr FY 1998	Begin Construction 1st Qtr FY 1997 Complete Construction 2bd Qtr FY 1998	Project provides for construction of an addition to the east end of the lower level of OPF-3 Annex.
Rehabilitation of 480V Electrical Distribution System	4th Qtr FY 1996 (Phase I) 3rd Qtr FY 1996 (Phase II)	1st Qtr FY 1997 (Phase I) TBD (Phase II)	The 480-volt electrical distribution system in building 103 was originally installed in the 1940's. This project will replace feeder cables and distribution panels and it contains the systematic rehabilitation of the older high voltage system in critical ET production areas. Phase I - Design Complete. Begin Construction. Phase II - Begin Design. Estimated time for design - 12 months.
Restore Pad B Fixed Service Structure	1st Qtr FY 1997	2nd Qtr FY 1997	This project replaces the elevator cabs, cables, and controls to eleminate severly deteriorated and archaic equipment. Design Complete. Begin Construction when Pad B mod window begins.
Replace LC-39 , Pad B Chiller	1st Qtr FY 1997	2nd Qtr FY 1997	This project replaces three existing facilíticy chillers and air handling units. Design Complete. Begin construction when Pad mod window begins.

Refurbishment of High Pressure Water System	1st Qtr FY 1997	4th Qtr FY 1996	Overhaul diesel engine for the water pumps and backup electrical power need to ensure system reliabillity and maintainability in support of the SSME test program as well as future testing. Design Complete. Begin construction.
Restore PCR Wall and Ceiling Integrity at LC-39A	2nd Qtr FY 1997	--	This project provides for replacement of damaged walls, leaking access door, ceiling/lighting improvements for safer accessibility and better environmental control of Payload Changeout Room Begin design.
Restore Launch Pad A Surface and Slopes at LC-39A	4th Qtr FY 1996	1st Qtr FY 1997	This project includes repair of cracks, repair/replacement of fractured and broken section of concrete. Begin Design

ACCOMPLISHMENTS AND PLANS

Budgetary pressures demand that proper investments are made to promote efficiency of operations while insuring that the critical element of safety is maintained as a primary goal. The FY 1998 budget request for Safety and Performance Upgrades is the result of a project prioritization process that addresses safety first, second it provides for performance enhancements, upgrades to prevent obsolescence and promote efficiency, and third. it addresses 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 (S&PU) 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. The S&PU budget will continue to support the replacement of the Orbiters' cockpit displays with Multifunction Electronic Display System (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 Johnson Space Center, testing of main engine components at SSC, testing of Orbiter reaction control systems at the White Sands Test Facility, and replacing critical subsystems in the Kennedy Space Center facility complex. At the Kennedy Space Center, phase two of the fire protection upgrade will be conducted as will replacement of the chemical analysis lab and improvement of the main engine processing facility.

In addition, this request includes funds for Shuttle Supportability Upgrades which will maintain availability of the Space Shuttle fleet into the next century and, at a minimum, through the planned life of the International Space Station (2012).

The Space Shuttle program rationale for supportability upgrades is founded on the premise that safety, reliability, and mission supportability improvements must be made in the Shuttle system to continue to provide safe and affordable operations into the next century. These will enable safe and efficient Shuttle operations during the Space Station era while providing a robust testbed for advanced technologies and a variety of customers.

The Space Shuttle Upgrade activity will be planned and implemented from a system-wide perspective. Individual upgrades will be integrated and prioritized across all flight and ground systems, insuring that the upgrade is compatible with the entire program and other improvements. Selection of new upgrades through the review process approved by the Associate Administrator for Space Flight, the Program Management Council (PMC) and the Administrator will be utilized. Implementation authority and responsibility will be delegated to the Lead Center Director for the Shuttle Program with the Shuttle Program Manager and the projects. Space Shuttle upgrades will be developed and implemented in a phased manner supporting one or more of the following program goals:

- Improve Space Shuttle system safety and/or reliability
- Support the Space Shuttle program manifest/Space Station
- Improve Space Shuttle system support
- Reduce Space Shuttle system operations cost

The phasing strategy will be coordinated with the Reusable Launch Vehicle (RLV) project management, and other development projects, to capture common technology developments, while meeting the Shuttle manifest. This phasing strategy should allow the incorporation of additional, more comprehensive upgrades to the Space Shuttle system while benefiting other programs and technologies. Definition activity leading to the selection of upgrade candidates will continue in FY 1997. Candidate upgrades in the initial phases will utilize state-of-the-art technology and provide safety/reliability, supportability, and/or cost (improvement) advantages. Candidate designs in the initial phases would maintain the current Shuttle mold lines and system/subsystem interfaces. Major system changes will likely require a definition period with the potential for the development of prototype systems.

Orbiter Improvements

Orbiter improvements provide for modifications and upgrades to ensure compatibility of the Space Shuttle vehicles with the new Space Station operational environment. Orbiter weight reductions have been identified where operating experience or updated requirements allow selected items to be changed without impact to crew safety or mission success. The Orbiter weight will be reduced by changing the exterior thermal protection materials on certain portions of the Orbiter, deleting portions of the Orbital Maneuvering and Reaction Control Systems (OMS/RCS) that are no longer required, changing the material on the "flipper doors" that provide a seal between the Orbiter wing and its control surfaces, and development of lighter weight crew seats for the cockpit.

Other improvements continue on the Orbiter internal systems. For example, the Auxiliary Power Unit gas generator valve module is undergoing redesign to improve its reliability; the thermal protection system certification will allow the leading edge of the wing to experience higher temperatures during reentry, a new vendor was qualified to provide remote power controllers, and enhancements for improving the Space Shuttle performance were initiated. The new Auxiliary Power Unit gas generator valve module will be ready for its first flight during the second quarter of FY 1997.

During FY 1996, Discovery (OV-103) completed its OMDP and will re-enter the fleet in time to fly STS-82 in February 1997. Endeavour (OV-105) followed Discovery and will complete the OMDP at the Palmdale, California facility for normal maintenance, structural inspections, and modifications for docking with the International Space Station, and is expected to be completed in April 1997. In FY 1998, Atlantis (OV-104) 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 19107'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, benefiting the training of new astronauts directly. Secondary benefits of MEDS are reductions in the Orbiter's weight and power consumption. The MEDS upgrade includes the design effort and production of modification kits for the four Orbiter vehicles. New MEDS ground support hardware is also being designed. When procured and installed it will upgrade the appropriate simulators, test equipment, and laboratories. MEDS will be installed in the Orbiters and tested during the planned OMDPs. The decision to make a switch to an alternate and more viable source for the Active Matrix Liquid Crystal Display Assemblies caused a six month delay in the first flight of a MEDS equipped Orbiter from July 1998 to January 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 1999.

In addition to modifying the Orbiter for Space Station operations, a self-rescue device was required to safely conduct Space Station extravehicular activity. Production of SAFER (Simplified Aid for Extravehicular Rescue) was initiated in FY 1995. SAFER will consist of a small propulsive backpack to be worn by each NASA-suited 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 Space Shuttle can easily fly to the rescue. However, the Mir and the Space Station will not be maneuverable enough to rescue an detached crew member, therefore, an autonomous self-rescue device must be provided. The SAFER unit provides the best overall 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 at JSC. The first operational use of SAFER is scheduled to be performed on a Space Shuttle-Mir docking flight STS-86/Mir-07 in FY 1997.

Propulsion Upgrades

The most complex components of the Space Shuttle Main Engine (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 Program (ATP) 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 expand existing safety margins and reduce operational costs. Significant progress was made once the bearings were tested, accepted and introduced into the ATP HPOTP, testing proceeded successfully with completion of certification testing and first flight was accomplished in FY 1995. Throughout FY 1996, the ATP HPFTP experienced several problems during testing relating to alpha frequency vibrations occurring inside the turbopump assembly. The magnitude of these vibrations have been improved but this problem has eluded our efforts to eliminate in FY 1996. Design improvements and development testing to improve this condition will continue in FY 1997. The high pressure fuel turbopump, restarted during FY 1995, is scheduled for completion and first flight in FY 1998.

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 II+ 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 II+ Powerhead also reduced 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 eliminated all seven critical welds and tripled the wall thickness of the tube.

The Large Throat Main Combustion Chamber (LTMCC) development will result in lower pressures and temperatures throughout the engine system thereby increasing the overall Space 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 increasing chamber life. The LTMCC design also incorporates new fabrication techniques to reduce the number of critical welds and improve the producibility of the chamber. Development on the powerhead, heat exchanger and LTMCC is all being performed under contract with the Rocketdyne division of the Boeing North American Corporation.

The "block" change concept for incorporating changes into the main engine was introduced and baselined during FY 1994. The Phase II+ 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 early FY 1998 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.

Increased 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.

The SLWT program is a result of NASA's desire to enhance the payload capability of the Space Shuttle to support the Space Station Program. In FY 1996, the verification testing of the Aluminum Lithium Test Article (ALTA) was successfully completed. This test demonstrated the capability of the liquid hydrogen barrel section of the SLWT to withstand flight loads with sufficient margin. During FY 1997, the SLWT will undergo final assembly and proof testing in preparation for delivery to KSC in September 1997. First flight is planned for December 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 of 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 Space 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 equipment upgrades.

The new Mission Control Center (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 Modules (HIM), which are electrical command distribution systems that support the launch processing system (LPS) at KSC, are over 25 years old and have experienced an increased failure rate and higher cost of repair over the past several years. The HIM upgrade will replace all chassis and cards with state-of-the-art "off the shelf" hardware to improve system reliability and maintainability. Production and installation should be complete in FY 1999.

A 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 1630s 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.

A launch processing system control, checkout and monitoring system study is underway to assess the best system architecture for the program given the MCC upgrade and advancements in technology. In order to meet the needs of the next century a new launch processing system is required. The current study will provide options as to the best approach to bring forward for approval as a Phase II or III upgrade.

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 of the Space Shuttle to launch within the five-minute window required for operations with the Space Station.

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 (CoF)

FY 1996 CoF funding was concentrated on KSC facilities. The new Chemical Analysis Facility replaces the existing facility which is overcrowded and is in non-compliance with OSHA fire safety standards. 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 protection pumps, motors, and diesels serving Launch Pads A and B fire protection system.

FY 1997 CoF funding is for facilities at KSC, MAF, and SSC. At KSC, there are two projects which are both at Launch Complex Pad B - 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 480-volt electrical system are necessary to protect critical manufacturing operations in the final assembly and major weld areas for the manufacturing of the External Tank (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.

FY 1998 CoF will provide for improvements for facilities at KSC and MAF. At MAF, this project is phase II of IV to rehabilitate the 480-volt electrical distribution system that is critical to the manufacturing of the external tank. At KSC, one project will be restoring the walls and ceiling that provides a controlled environment to perform pre-flight services of Space Shuttle hardware at Pad A/LC-39 Payload Change-Out Room (PCR). The other project at KSC will restore the concrete surfaces and slope of Pad A/LC-39 structure. For additional details on these projects, please refer to the Mission Support - Construction of Facilities budget.

SHUTTLE OPERATIONS

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
Orbiter and integration	**521,000**	**516,600**	**463,100**
(Orbiter)	(378,500)	(375,400)	(356,100)
(System integration)	(142,500)	(141,200)	(107,000)
Propulsion	1,061,500	1,098,700	1,136,900
(External tank)	(327,500)	(339,000)	(359,700)
(Space shuttle main engine)	(185,000)	(182,300)	(184,900)
(Reusable solid rocket motor)	(395,700)	(427,000)	(434,600)
(Solid rocket booster)	(153,300)	(150,400)	(157,700)
Mission and launch operations	902,900	899,600	894,400
(Launch and landing operations)	(544,000)	(609,900)	(605,300)
(Mission and crew operations)	(358,900)	(289,700)	(289,100)
Total	**2,485,400**	**2,514,900**	**2,494,400**

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 1997 planned standard service reimbursements total $18.8 million, with $7.0 million in reimbursements assumed for FY 1998, which offset the budget for the Space Shuttle, and have been assumed in the budget request.

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 (NSI's), and overhauls and repairs associated with the Remote Manipulator System (RMS); and

(5) The sustaining engineering associated with the Orbiter vehicles.

The major contractors for these Orbiter activities are United Space Alliance for operations; Boeing North American for 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) and conducted primarily by United Space Alliance, 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, funding is provided for Multi-program support at JSC.

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 and necessary environmental manufacturing improvements.

(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 Boeing North American 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.

USBI, Inc. is the prime contractor on the SRB and conducts SRB retrieval, refurbishment and processing at KSC. USBI is in the process of consolidating their workforce at Kennedy Space Center from Huntsville, Alabama, and plans to complete the transition in FY 1997.

The Reusable Solid Rocket Motor (RSRM) project includes:

(1) Purchase of solid rocket propellant and other materials to manufacture motors and nozzle elements.

(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). The primary contractor is United Space Alliance. 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 primary contractor is US Alliance. 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;

(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 (Space 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 Space Shuttle Operations is to provide safe, reliable, and effective access to space. Space Shuttle operations are manifested at a planned rate of seven flights per year from FY 1997 through FY 1998. For FY 1999 through 2000, the flight rate is eight per year, with seven flights per year thereafter.

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.

United Space Alliance (USA) was awarded the Space Flight Operations Contract (SFOC) on September 28, 1996. It includes a phased approach to consolidating operations into a single prime contract for operational activities. The first phase began in late 1996 with 12 operational and facility contracts being consolidated from the majority of the effort previously conducted by Lockheed Martin and Boeing North American (the two corporations which comprise the US Alliance joint venture). 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. Transition will take another 1-2 years and employ approximately 7300 equivalent persons at steady state. All transitions will be completed in FY 2000. The reasons for this phased approach are two-fold:

1. The ongoing major development projects (e.g. SLWT, MEDS, ATP, etc.) will be completed.

2. The transition to the prime can occur at a more measured pace.

The roles and missions of the contractor and government relationships have been defined to insure program priorities are maintained and goals are achieved. The SFOC contractor is responsible for flight, ground, and mission operations of the Space Shuttle. The accountability of its actions and those of its subcontractors will be evaluated and incentivized through the use of a combined award/incentive fee structure of the performance-based contract. NASA as owner of assets, customer of operations services, and director of launch/flight operation, is responsible for (a) surveillance and audit to ensure compliance with SFOC requirements, and (b) internal NASA functions. Further, NASA will retain chairmanship of control boards and forums responsible for acceptance/rejection/waiver of Government requirements while the SFOC contractor is responsible for requirement implementation. The SFOC contractor is required to document and maintain process/controls necessary to ensure compliance with contract requirements and to sign a certification of flight readiness (CoFR) to that effect for each flight.

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 on-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.

Operations Metrics	**FY 1996**	**FY 1996**	**FY 1997**	**FY 1997**	**FY 1998**
	Revised Plan	Actual	Plan	Current	Plan
Number of Space Shuttle Flights	7	8	7	7	7
Shuttle Operations Workforce (Prime Contractors)*	16,707	16,707	15,961	16,519	16,478
Space Shuttle Processing Overtime Required	3%	3%	3%	3%	3%
Number of Days On-orbit	90	94	80	84	76
Number of Primary Payloads Flown	12	12	9	9	8

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

Space Shuttle Missions and Primary Payloads

FY 1996		**Plan**	**Actual**
STS-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	March 1996
STS-77/Endeavour	Spacehab-4	May 1996	May 1996
STS-78/Columbia	Life/Microgravity Sciences (LMS-1)	June 1996	June 1996
STS-79/Atlantis	Russian Space Station Mir (Mir-4)	August 1996	September 1996
FY 1997		**Plan/Revised**	**Actual**
STS-80/Columbia	Wake Shield Facility-3 (WSF-3)/OREFUS-SPAS-02	November 1996	November 1996

STS-81/Atlantis	Russian Space Station Mir (Mir-5)/Spacehab	December 1996	January 1997
STS-82/Discovery	Hubble Space Telescope Servicing Mission (MST SM-02}	February 1997	--
STS-83/Columbia	Microgravity Science Laboratory (MSL-1)	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 1998		**Plan**	**--**
STS-87/Columbia	Microgravity Payload (USMP-04)/Spartan 201-04	October 1997	--
STS-88/Endeavour	Space Station #1 (Node 1) (ISS-01-2A)	December 1997	--
STS-89/Endeavour	Russian Space Station Mir (Mir-8)/Spacehab	January 1998	--
STS-90/Columbia	Neurolab	March 1998	--
STS-91/Discovery	Russian Space Station Mir (Mir-9)/Spacehab	May 1998	--
STS-92/Endeavour	Space Station #2 (ITS Zi) (ISS-02-3A)	July 1998	--
STS-93/Columbia	AXAF	August 1998	--

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

In FY 1996, 50 U.S. crew members lived and worked in orbit for a total of 797 days, including time spent by an American astronaut aboard Mir. 42 crew members will fly 867 crew days in FY 1997 and 649 crew days are planned for in FY 1998.

To supplement the network of management reviews and government oversight functions, NASA continues to seek specific objective measurements for overall performance of the Space Shuttle program. In order to permit rapid review by the program director and program 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, Space Shuttle processing monthly mishaps, Orbiter systems and Line Replaceable Unit (LRU) problem reports, Space Shuttle processing contract overtime percentage, and Kennedy Space Center (KSC) quality surveillance error rate. The Space Shuttle program also tracks its launch history, monitoring the number of liftoff attempts per mission and characterizing any delays or scrubs as technical, weather or operational-related reasons.

ACCOMPLISHMENTS AND PLANS

In FY 1996, the Space Shuttle launched eight flights successfully including three flights to the Russian Mir Space Station. Additional flights deployed the Tether Satellite System, conducted a USMP mission and flew two Spacelab missions. The Japanese Space Flyer Unit was retrieved and many science and commercial development experiments were conducted in conjunction with the fourth Spacehab mission.

At the end of FY 1996, United Space Alliance (USA) was awarded the Space Flight Operations Contract (SFOC) on September 28, 1996. as the Space Shuttle single prime contractor. This begins Phase I of the operations consolidation wherein the major ground and flight operations work done today by Lockheed Martin and Boeing North American will be consolidated into a single program contract. This also initiates 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").

The seven flights manifested for FY 1997 include a Wake Shield experiment which was successfully flown in November 1996, and three more resupply flights to the Russian Space Station Mir. The Space Shuttle will make a second servicing visit to the Hubble Space Telescope in February 1997 replacing two current science instruments with "second generation" instruments and refurbishing some telescope support system components. The Space Shuttle will also support a development flight test of components 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 experiments.

Seven flights will be flown during FY 1998, including two International Space Station assembly flights. In addition the last Spacelab mission (NEUROLAB) will be flown, in which the Space Shuttle crew will investigate the effects of weightlessness on neurological processes using both human and animal specimens. Another flight will deploy the Advanced X-Ray

Astrophysics Facility (AXAF). Two Spacehab flights during FY 1998 to the Mir Space Station are also manifested. Another mission includes a Microgravity payload package of experiments in the Orbiter cargo bay and a SPARTAN X-ray astronomy experiment using a retrievable free flyer.