HUMAN SPACE FLIGHT

FISCAL YEAR 2001 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE SHUTTLE**

	FY 1999 OPLAN 12/23/99	FY 2000 OPLAN REVISED	FY 2001 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Safety and Performance Upgrades	571,600	488,800	--	HSF 2-6
Shuttle Operations	2,426,700	2,490,700	--	HSF 2-21
Flight Hardware	--	--	2,005,900	HSF 2-27
Ground Operations	--	--	551,800	HSF 2-32
Flight Operations	--	--	273,600	HSF 2-35
Program Integration	--	--	334,400	HSF 2-38
(Safety Allocation including upgrades - non-add)	--	--	(256,400)	
Total	2,998,300	2,979,500	3,165,700	
Distribution of Program Amount by Installation				
Johnson Space Center	1,721,400	1,658,900	1,768,100	
Kennedy Space Center	173,300	185,800	222,600	
Marshall Space Flight Center	1,050,500	1,079,900	1,131,900	
Stennis Space Center	38,100	40,300	30,000	
Dryden Flight Research Center	4,600	4,800	4,800	
Ames Research Center	3,500	4,500	3,000	
Langley Research Center	200	200	200	
Glenn Research Center	200	0	0	
Goddard Space Flight Center	2,300	100	100	
Jet Propulsion Laboratory	300	0	0	
Headquarters	3,900	5,000	5,000	
Total	2,998,300	2,979,500	3,165,700	

Note: This FY 2001 Request is submitted in a restructured budget format for the Space Shuttle Program. Please see the Special Issues section for more details.

GENERAL

The Shuttle Operations program provides launch services to a diverse set of customers, supporting launch, on-orbit operations, and return to earth, of payloads that range from small hand-held experiments to large laboratories. While most missions are devoted to NASA-sponsored payloads, others including industry, partnerships, corporations, academia, national and international agencies exercise wide participation. NASA, and the U.S. and international scientific communities are beneficiaries of this approach. The Space Shuttle is a domestically and internationally sought-after research facility because of its unique ability to provide on-orbit crew operations, rendezvous/retrieval and payload provisions, including power, telemetry, pointing and active cooling.

The Space Shuttle continues to prove itself to be the most versatile launch vehicle ever built. This has been demonstrated by: (1) rendezvous missions with the Russian Space Station Mir; (2) advancing life sciences and technology through long-duration Spacelab and Spacehab missions; and (3) repairing and servicing the Hubble Space Telescope, enabling many new discoveries in Space Science. The Space Shuttle has also performed rescue and retrieval of spacecraft and has begun the assembly of the International Space Station. The Space Shuttle services numerous cooperative and reimbursable payloads involving foreign governments and international agencies. The focus of international cooperation, for which the Space Shuttle is uniquely suited, is the assembly and operational support of the International Space Station (ISS), already underway with the first ISS assembly mission, STS-88, successfully completed.

The Shuttle Operations program participates in the domestic commercial development of space, providing limited 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. Cooperative activities with the National Institutes of Health (NIH), the National Science Foundation (NSF), the Department of Defense (DoD) and other U.S. agencies are advancing knowledge of health, medicine, science and technology. Prime examples include Space Shuttle support for the flight of STS-95 in FY 1999 with Senator John Glenn, many cooperative NASA-NIH experiments and the Shuttle Radar Topography Mission, a joint DoD/NASA payload, now scheduled in FY 2000.

The restructuring activities of the past seven years have resulted in an annual funding reduction of about 30% from FY 1993 to FY 1999, and a 32% reduction in the shuttle workforce since FY 1992. In addition, after 96 successful missions, a significant reduction in operational requirements is continuing. Consolidation of contracts to a single prime contract is progressing successfully since the award of the Space Flight Operations Contract (SFOC) on October 1, 1996. Phase II of the transition is now underway, with the first production hardware contract (Solid Rocket Booster) transferred into SFOC in FY 1998. The remaining schedule for further transition is under review.

Continued safe operation of the Space Shuttle is a high priority, in particular to ensure the Space Shuttle's ability to support assembly and operations of the International Space Station. Investments in Shuttle safety improvements have been made over the last several years while, at the same time, the Shuttle budget was reduced by about a third through efficiencies and contract consolidation. Having achieved these reductions, continued improvements in Shuttle safety will require additional investment. Therefore, this request augments the NASA budget with investments that will continue to significantly improve safety and protect the nation's investment in the Station and Shuttle. There are two elements to the increase in Shuttle safety funding. First, the FY 2001 budget includes a $51 million increase in the Research and Program Management line of the Mission Support account for additional personnel at NASA's Human Space Flight centers to ensure that the right skills and staffing levels are in place to launch and assemble the Station. Second, a $256.4 million Safety Allocation is requested in the FY 2001 Space Shuttle budget to address Shuttle safety improvements through hardware/software upgrades, personnel, facility, or other investments. This is significant increase over $100 million per year for Shuttle upgrades that was in previous requests.

NASA will be conducting an external review to assess how the Safety Allocation funds can most effectively be used to improve the safety of the Space Shuttle. NASA will proceed with the three highest priority upgrade activities, and additional activities may be started pending results of the external review. The three highest priority upgrades include two with firm plans: the electric auxiliary power unit (EAPU), and advanced health monitoring for the Space Shuttle main engines (SSME). These two upgrades alone will improve Shuttle safety during ascent from the current 1 in 438 chance of catastrophic failure to 1 in 735. The third of the highest priority upgrades, which is still under study, is for improved avionics in the Shuttle cockpit. This will improve the situational awareness of the crew, and better equip them to handle potential flight anomalies. Additional upgrades will be assessed as part of the external review, and candidates include additional upgrades to the SSME, advanced thrust vector control for the solid rocket boosters, and others.

Space Shuttle safety investments are an important element of NASA's strategy for an overall Space Launch Initiative. These investments ensure continued safe Shuttle operations through this decade, and provide assurance that the Shuttle could operate into the next decade, if needed.

The Space Shuttle operations prime contractor, United Space Alliance, was awarded the Space Flight Operations Contract (SFOC) on October 1, 1996 based upon a phased approach to consolidate 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 USA 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.. The specific schedule for all transitions is currently under review. The reasons for this phased approach are two-fold:

1. The ongoing major development projects 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 ensure 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 operations, is responsible for (a) surveillance and audit to ensure compliance with SFOC requirements and (b) internal NASA functions. Further, NASA retains 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 processes/controls necessary to ensure compliance with contract requirements and to sign a certification of flight readiness (CoFR) to that effect for each flight.

This FY 2001 Request is submitted in a restructured budget format for the Space Shuttle Program. There are several reasons why this new structure is beneficial. First and foremost, as the Program has become more operational in nature and undergone consolidation of its contracts into a single operational contract approach; the budget should reflect the way in which the Program is managed. The Space Shuttle Program is an operational effort, therefore, a structure consistent with the nature and maturity of the program is being implemented. Also, the four major budget elements of Flight Hardware, Ground Operations, Program Integration and Flight Operations are consistent with the Space Flight Operations Contract (SFOC) Work Breakdown Structure. This consistency improves NASA's ability to account for and reconcile the work accomplished and expenditures. Another benefit to the new structure is the old nomenclature, "Safety and Performance Upgrades" (S&PU), will no longer be used as a budgetary naming convention. The new structure provides much more clarity with the Upgrades activity and recent augmentations included in this request. The S&PU as a budget category included many other items in addition to Upgrades, which led to confusion as to what were and were not considered upgrades. Under the new structure, upgrades are clearly delineated under each of the four line items.

PROGRAM GOALS

The primary goals of the Shuttle Operations program in priority order are: (1) fly safely; (2) meet the flight manifest; (3) improve supportability and (4) improve the system.

NASA policy planning assumes the Space Shuttle will need to be capable of supporting the critical transportation requirements for at least the next decade including the assembly of the Space Station and Space Station operations. In order to maintain a viable human transportation capability that will operate into this new century and support NASA's launch requirements, specific program investments are required. These investments are consistent with NASA's strategy of ensuring the Space Shuttle remains viable until a new transportation system is operational.

STRATEGY FOR ACHIEVING GOALS

All decisions regarding program requirements, programmatic changes and budget reductions are guided by the program's goals as stated above. Three key elements of this budget request are: (1) the continued transition to a single prime contractor for space flight operations; (2) continuation of safety and supportability upgrades; and (3) Orbital Maintenance Down Periods (OMDPs) to be conducted at Palmdale, California.

The overall strategy for the Shuttle Operations budget is to request funding levels sufficient to allow the Space Flight Operations Contract to meet the intended flight rates. This includes appropriate contingency planning in both budget and schedule allowances to assure transportation and assembly support to the Space Station program. At the same time it also incentivizes the contractor to identify opportunities for reductions in operations costs while still ensuring the safe and reliable operation of the Space Shuttle. The continued transition of activities to the Space Flight Operations Contract represents a key element of this strategy.

This budget is based on an average of seven flights annually with a surge capability to nine flights and remains essentially unchanged from previous years. Although FY 1999 had only four flights and six flights are planned for FY 2000, FY 2001 is a nine-flight year and includes seven International Space Station (ISS) assembly and utilization flights, the remainder of the third Hubble Space Telescope servicing mission and a dedicated microgravity research mission. The flight rate is anticipated to continue at 8 to 9 per year through FY 2004 without any significant increase in this budget. This manifest supports the Nation's science and technology objectives through scheduled science missions and continued assembly of the ISS.

In addition to flying safely, restructuring the program and conducting a single prime consolidation, we are completing activities that have been in the Safety and Performance Upgrades program, and transitioning to a new budget structure which integrates safety and supportability upgrades into the four major budget elements. The Shuttle Operations program's strategy for the Safety and Performance Upgrades budget has been to fund those modifications and improvements which will provide for the safe, continuous and affordable operations of the Space Shuttle system for the foreseeable future. This is an essential element of the launch strategy required for continuing supportability to the ISS. Completion of selected projects, termed "Phase I" upgrades, has improved Space Shuttle safety and payload-to-orbit performance by 13,000 pounds. The additional payload-to-orbit performance allows the Shuttle to achieve the orbital inclination and altitude of the International Space Station. The largest of these projects was the Super Light Weight Tank (SLWT) which was successfully flown on STS-91. All Phase I upgrades are complete and have met the performance requirements of the first Space Station assembly flight, STS-88, in the 1st quarter of FY 1999.

In the Space Shuttle's FY 1999 Congressional request, the Agency had formed a Space Transportation Council (STC) to assess advanced transportation areas in both the Office of Space Flight and the Office of Aeronautics and Space Transportation Technology. In recognition of the value of close collaboration on the technology needs of future reusable launch vehicles, lead responsibility has been consolidated within the Space Transportation Technology program. The Space Transportation Council will provide management oversight and policy direction across the agency's activities in this area. Potential major Shuttle upgrades will be examined under the Future Space Launch industry-led trade studies described in the Space Transportation Technology section. These studies will provide the basis for decisions by NASA and the Administration on pursuing a future operational launch strategy to purchase launch services from privately owned and operated launch systems, to further reduce NASA's launch costs.

This budget also includes Supportability upgrades to develop systems, which will combat obsolescence of vehicle and ground systems in order to maintain the program's viability into this new century. Vendor loss, aging components, high failure rates of older components, high repair costs of Shuttle-specific devices and negative environmental impacts of some outdated technologies are areas to be addressed.

This budget provides funds required for modifying and improving 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 capital investments needed to achieve reductions in operational costs. The Block IIA engines flew on STS-89 in January of 1998. Work continues on the Alternate Fuel Turbopump for the planned introduction of the Block II Space Shuttle Main Engine (SSME) in FY 2000.

BASIS OF FY 2001 FUNDING REQUIREMENT

SAFETY AND PERFORMANCE UPGRADES

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Orbiter improvements	234,800	183,700	--
Multifunction-electronic display system	9,800	--	--
Other orbiter improvements	188,300	105,200	--
Upgrades	36,700	78,500	--
Propulsion upgrades	175,700	213,200	--
Space shuttle main engine upgrades	167,200	151,100	--
[Alternate Turbopump program]	[56,900]	[41,300]	[--]
[Large Throat Main Combustion Chamber]	[6,500]	[1,400]	[--]
[Phase II+ Powerhead Retrofit]	[4,500]	[2,700]	[--]
[Other main engine upgrades]	[99,300]	[105,700]	[--]
Solid rocket booster improvements	2,600	1,900	--
Super Lightweight tank	1,100	500	--
Upgrades	4,800	59,700	--
Flight operations & launch site equipment upgrades	147,600	80,900	--
Flight operation upgrades	46,100	29,600	--
Launch site equipment upgrades	48,000	2,700	--
Upgrades	53,500	48,600	--
[Checkout and Launch Control System] [included above]	[50,000]	[39,800]	[--]
[Other Upgrades] [included above]	[3,500]	[8,800]	[--]
Construction of Facilities	13,500	11,000	--
Total	571,600	488,800	--

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 overall operation of the Space Shuttle System. Success depends on developing these projects and getting them implemented to help ensure the Space Shuttle's safe operation and improving the reliability of the supporting elements.

This FY 2001 Request is submitted in a restructured budget format for the Space Shuttle Program. The old nomenclature, "Safety and Performance Upgrades" (S&PU), will no longer be used as a budgetary naming convention. The new structure provides much more clarity with the Upgrades activity and recent augmentations included in this request. The S&PU as a budget category included many other items in addition to Upgrades, which led to confusion as to what were and were not considered upgrades. Under the new structure, upgrades are clearly delineated under each of the four line items of Flight Hardware, Ground Operations, Program Integration and Flight Operations.

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 less 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 Boeing Reusable Space Systems (as a major subcontractor to United Space Alliance (USA)) in two major locations: the Huntington Beach, California facility provides engineering support; and the Palmdale, California operation provides Orbiter Maintenance Down Period (OMDP) support as discussed below, as well as manufacturing and testing. 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 Sundstrand.

An Orbiter Maintenance Down Period (OMDP) occurs when an 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 Boeing Reusable Space Systems is responsible for operating three locations that provide engine manufacturing, major overhaul, components 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.

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 and the T-38 aircraft.

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). The most significant upgrade in this account is the Checkout and Launch Control System (CLCS) at KSC.

Construction of Facilities

Construction of Facilities (CofF) funding for Space Shuttle projects is provided in this budget to refurbish, modify, reclaim, 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 policy planning assumes the Space Shuttle will need to be capable of supporting the critical transportation requirements for at least the next decade including the assembly of the Space Station and Space Station operations. In order to maintain a viable human transportation capability that will operate into this new century and support NASA's launch requirements, specific program investments are required. These investments are consistent with NASA's strategy of ensuring the Space Shuttle remains viable until a new transportation system is operational.

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 capital investments needed to achieve reductions in operational costs. The Block IIA engines flew on STS-89 in January of 1998. Work continues on the Alternate Fuel Turbopump for the planned introduction of the Block II Space Shuttle Main Engine (SSME) in FY 2000.

SCHEDULES AND OUTPUTS

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 to help ensure the Space Shuttle's safe operation, improving the performance and 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

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.

MEDS Initial Operational Capability (IOC) Plan: 2nd Qtr FY 1999 Revised: 2nd Qtr FY 2000	First flight of a MEDS equipped Orbiter. (OV-104/STS-101)

Global Positioning System (GPS) - GPS will replace the current TACAN navigational system in the Orbiter navigation system when the military TACAN ground stations will be phased out. The planned readiness date for the Space Shuttle's system is FY 2001.

Orbiter Install Complete Plan: 4th Qtr FY 1998 Revised: 2nd Qtr FY 1999	Installation and checkout of hardware on OV-104 at Palmdale.
Complete GPS operational Capability Plan: Under Assessment	Initial operation of GPS without TACAN system. (Under Assessment.)

Orbiter Maintenance Down Periods/Orbiter Major Modification (OMDP/OMM)

Initiate Columbia (OV-102) OMDP Plan: 3rd Qtr FY 1999 Revised: 4th Qtr FY 1999	Conduct routine maintenance and structural inspection. Also, install the MEDS upgrade, hardware for 3-string GPS capability and OV-102 scarring mods.

Initiate Discovery (OV-103) OMDP Plan: 3rd Qtr FY 2000 Revised: 1st Qtr FY 2002	Conduct routine maintenance and structural inspection. Also, install the MEDS upgrade, hardware for 3-string GPS capability.

Propulsion Upgrades

<u>Space Shuttle Main Engine Safety Improvements</u> - Introduction of the Block I and Block II changes into the Space Shuttle's Main Engine (SSME) program will improve the SSME margin of safety by a factor of two. The interim Block IIA configuration (Block II without the ATP High-Pressure Fuel Turbo Pump (HPFTP)) implements the safety and performance margins provided by the Large Throat Main Combustion Chamber (LTMCC) while the HPFTP development problems are solved.

High Pressure Fuel Turbopump CDR Plan: 3rd Qtr FY 1996 Revised: 3rd Qtr FY 1998	Completion of Critical Design Review (CDR) will allow production to proceed for implementation of the Alternate Turbopump high pressure fuel pump into the Block II Engine upgrade. Revised due to design delays
First flight of Block II engine Plan: 4th Qtr FY 1997 Revised: 1st Qtr FY 1998 Revised: 4th Qtr FY 2000	The high pressure fuel turbopump will be combined with the LTMCC and previous Block I upgrades. Revised due to testing delays

<u>Flight Operations and Launch Site Equipment Upgrades-</u> Upgrades to the Mission Control Center were completed in FY 1998 period which improved operations reliability and maintainability and also took advantage of the state-of-the-art technology in displays and controls. In addition, upgrades continued in FY 1998 to the Launch Site Equipment at KSC, which will increase reliability and reduce obsolescence.

CLCS "Atlas" Delivery Plan: 2nd Qtr FY 1999 Actual: 1st Qtr FY 2000	The Atlas delivery represents the first fully operational delivery for the project. This delivery will allow the start of usage of a CLCS set of hardware, system software and application software for processing of Space Shuttle components in the Hypergolic Maintenance facility at KSC.
SAIL set installation Plan: 2nd Qtr FY 1999 Actual: 3rd Qtr FY 1999	The CLCS Shuttle Avionics Integration Lab (SAIL) set completed facility modifications and hardware installation and activation. This set will be used to validate CLCS application software against real flight-like hardware.
First Launch Using CLCS Plan: Under review	Launch the first Shuttle from a CLCS - equipped Launch Control Center.

Complete Migration of CLCS to all Firing Rooms and Simulators Plan: Under review	CLCS fully operational for flight support. This will result in a significant reduction in operating cost, up to 50%, of the current Launch Processing System.

Space Shuttle Safety Upgrades - New upgrades are being initiated by the Space Shuttle program to help ensure continued safe operations of the Space Shuttle by improving the margin of safety. The dates are planning estimates rather than commitments, as the program is still in an early definitional phase, but all new Space Shuttle safety upgrades will be fully in place on the Shuttle fleet by FY 2005. The Space Shuttle program is in the process of developing detailed project plans.

<u>Electric Auxiliary Power Unit (APU) – Orbiter</u> - Battery powered electric motors will replace turbines powered by hydrazine, a highly flammable and environmentally hazardous fluid. The turbines are used to drive the hydraulic pumps providing control for the orbiter such as engine movement, steering, and braking functions. The upgrade eliminates hydrazine leakage/fire hazards, eliminates turbine overspeed hazards, and reduces toxic materials processing hazards.

Electric APU Start
Plan: 4th Qtr FY 1999
Actual: 4th Qtr FY 1999

<u>Space Shuttle Main Engine (SSME) Advanced Health Monitoring (AHM)</u> - Another new safety upgrade, this project entails a suite of instrumentation, software, and computational capabilities for real-time engine assessment, rapid turnaround, and reduction in invasive, manual processing and testing. The system includes vibration monitoring, engine performance monitoring, engine exhaust plume analysis, and overall health analysis. It consists of two phases; Phase I reduces pump failures, Phase II mitigates engine.

SSME AHM Phase I Start
Plan: 1st Qtr FY 2000
Actual: 1st Qtr FY 2000

SSME AHM Phase I Preliminary Design Review
Plan: 3rd Qtr FY 2000

SSME AHM Phase I Critical Design Review Plan: 4th Qtr FY 2000	Completion of Critical Design Review will allow drawings to be released for production to proceed.

SSME AHM Phase II Start
Plan: 2nd Qtr FY 2000

<u>Avionics/Cockpit/Safety Implementation</u> - This new safety upgrade improves crew situational awareness and reduces flight crew workload. It provides automated control of complex procedures and increases the level of flight crew autonomy. Functional capabilities include enhanced Caution & Warning (a system to monitor critical instrumentation parameters), abort situation

monitoring and trajectory assessment, improved integrated vehicle instrumentation displays, Remote Manipulator System (RMS) safety enhancements for the robotic arm, and rendezvous and proximity operations.

Avionics/Cockpit Start
Plan: 1st Qtr FY 2000
Actual: 1st Qtr FY 2000

<u>Construction of Facilities</u>

Complete Phase I Restore Firex Pumps and Piping at LC-39 Plan: 3rd Qtr FY 1999 Actual: 4th Qtr FY 1999	Restoration is needed. Pumps are currently inadequate to provide spray coverage during an emergency. This project replaces underrated firex loop piping and components, and provides fire protection for the Orbiter Mid-Body Umbilical Unit (OMBUU) at Pads A and B. Additional work was necessary to complete the associated controls, including control cable installation and termination on Pad B. Final work scheduled to be complete during Pad A modification period in FY 1999.
Complete Phase II Restore Firex Pumps and Piping at LC-39 Plan: 3rd Qtr FY 1999 Revised: 2nd Qtr FY 2000	Restoration is needed. Pumps are currently inadequate to provide spray coverage during an emergency. This project removes and replaces existing Firex pumps, motors, refurbishes diesels, and installs a new underground pipe between the pump station and Pads A and B. Delayed due to scope and funding transfer from KSC to JSC/SFOC to complete project.
Rehabilitation of 480V Electrical Distribution System at MAF	External Tank manufacturing building Rehabilitation of the 480V Electrical Distribution System is a 4 phase project. Each phase will be implemented in the main manufacturing areas of building 103. Project Phasing and scope for each phase:
Complete Phase I Plan: 2nd Qtr. FY 1999 Actual:	Phase l, Final Assembly Area Project will upgrade the power distribution system from below the substation to the respective tools (labor-intensive project working over flight hardware).
Complete Phase II Plan: 1st Qtr. FY 2000 Actual: 1st Qtr. FY 2000	Phase II, ET Sub-Assembly Area Project will upgrade the power distribution system from below the substation to the respective tools.
Start Phase III Plan: 1st Qtr. FY 1999 Actual: 1st Qtr. FY 1999	Phase III, Substations Nos. 17A/17B will replace the core system, Transformers and switch gear, breakers and oil switches. Include some down stream cable, cable tray and panel upgrades. Planned completion date is 1st Quarter FY 2001.
Start Phase IV Plan: 1st Qtr. FY 2000	Phase IV, Substations Numbers, 7B, 4 & 5 - core system, transformers and switch gear, breakers and oil switches. Planned completion date is 2nd Quarter FY 2001.
Complete Pad B Chiller Replacement at LC-39 Plan: 2nd Qtr. FY 99 Actual: 3rd Qtr. FY 99	This project replaces the aged facility chillers at Launch Complex 39, Pad B, and reconfigures the system for more efficient maintenance.

Complete Rehabilitation of High Pressure Industrial Water System at SSC Plan: 2nd Qtr. FY 99 Actual: 2nd Qtr. FY 99	This project initiates the restoration of the High Pressure Industrial Water Plant to ensure system reliability in support of the Space Shuttle Main Engine testing.
Restoration of Pad A PCR Wall and Ceiling Integrity at LC-39 Start Plan: 1st Qtr. FY 99 Actual: 1st Qtr. FY 99 Complete Plan: 1st Qtr. FY 00 Actual:	This project provides for repair and replacement of damaged PCR wall Panels (Sides 1, 2, 3, & 4), replacement or elimination of deteriorated and leaking access doors and other needed replacement and restoration. The modification will eliminate degrading flexducts and filter housings, improve pressurization of the PCR, provide an even distribution of airflow and provide safe personnel access for maintenance and repair.
Pad A Surface and Slope Restoration at LC-39 Start Plan: 1st Qtr. FY 99 Actual: 1st Qtr. FY 99 Completion Plan: 1st Qtr. FY 00 Actual:	This project provides for repair of the Pad A surface concrete, pad slopes and the crawlerway grid path.
Start Repair of Pad A Flame Deflector & Trench at LC-39 Start Plan: 1st Qtr. FY 99 Actual: 1st Qtr. FY 99	This project provides for repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members and repair/replacement of bricks in the Flame Trench wall.
Complete Repair of Pad A Flame Deflector & Trench at LC-39 Plan: 1st Qtr. FY 2000 Revised: 4th Qtr. FY 2000	This project provides for repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement of bricks in the Flame Trench wall.
Start Pad A FSS Elevator restoration at LC-39 Plan: 1st Qtr. FY 99 Actual: 1st Qtr. FY 99	This project modifies the elevator structural on Pad A and refurbishes the elevator cabs, cables and cableway.
Complete Pad A FSS Elevator restoration at LC-39	This project modifies the elevator structure on Pad A, and refurbishes the elevator cabs, cables and cableway.

Plan: 1^{st} Qtr. FY 00
Actual: 1^{st}. Qtr. FY 00

Start Pad B Surface and Slope Restoration at LC-39
Plan: 2^{nd} Qtr. FY 2000
Actual: 1^{st} Qtr. FY 99

This project provides for repair of the Pad B surface concrete, pad slopes and the crawlerway grid path.

Cell E Restoration Start
Plan: 3^{rd} Qtr FY 99
Actual: 3^{rd} Qtr FY 99

This project restores and modifies the common solution return systems and lining for the cell. The cell lining is breaking down and requires restoration work at Michoud Assembly Facility.

Towway Support (Phase II) Start
Plan: 2^{nd} Qtr. FY 99
Actual: 2^{nd} Qtr. FY 99

This project is the SSP portion of the Support Facility at the Towway of the SLF. This project will refurbish the SLF Convoy Operation's capability at the SLF. Scheduled for completion in the 4^{th} Quarter of FY 2000.

Start VAB and Crawlerway Modification, LC-39 (Safe Haven) Start: Plan: 4th Qtr. FY 99 Actual: 4th Qtr. FY 99	This project restores the crawlerway into VAB highbay 2 and provides an Orbiter towway into Highbay 4. Partial stack access will be provided for in Highbay 2 and Orbiter storage and access will be provided for in Highbay 4. This will allow use of the VAB highbays as a safe haven during hurricanes, allow for additional manifest flexibility for stacking operations and Orbiter access operations to continue when Highbay 1 and 3 contain full stacks.
Start Repair VAB Elevator Controls Plan: 2nd Qtr. FY 00	This Project replaces the elevator systems in the Vehicle Assembly Building. The controls, cabs and cableway systems are obsolete and parts are no longer available. A recent fire in one of the VAB elevator controls caused a concern with the safety of the systems. This was identified as a safety project.

ACCOMPLISHMENTS AND PLANS

A significant portion of the Safety and Performance Upgrades (S&PU) budget has been dedicated to preventing the 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 supports replacing Tactical Airborne 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 Stennis Space Center, testing of Orbiter reaction control systems at the White Sands Test Facility and replacing critical subsystems in the Kennedy Space Center facility complex.

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 is planned and implemented from a system-wide perspective. Individual upgrades are integrated and prioritized across all flight and ground systems, ensuring 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 is utilized. Space Shuttle upgrades are 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

The phasing strategy is coordinated with the Reusable Launch Vehicle (RLV) project management and other development projects to capture common technology developments while meeting the Shuttle manifest.

Safety

Micrometeoroid Protection (discussed more thoroughly in Orbiter Upgrades, below)

- isolation valves for the radiator cooling loops to increase orbiter survivability
- "armoring" the radiator panels
- putting additional thermal protection on the wing leading edges to make them more damage tolerant

Orbiter Improvements

The Space Shuttle Program performs hundreds of modifications throughout the year related to design changes to improve reliability, supportability, or meet new program requirements. These changes are a result of hardware failures or design enhancements identified through ground checkouts or in-flight. Additional orbiter modifications are approved as the International Space Station development advances and risk mitigation options are identified and implemented. The modifications are implemented either during a standard orbiter processing flow at Kennedy Space Center in Florida or during Orbiter Maintenance Down Period at Palmdale, California.

OV-102 has just entered into its major modification and structural inspection at NASA's Palmdale facilities. The major modification to be performed this period are the installation of the multifunctional electronics display system and the scar for a three string global positioning system.

To increase the space shuttle weight to orbit performance in support of International Space Station flights, the space shuttle program implemented a variety of orbiter weight reduction modifications. The project consisted of converting a variety of orbiter hardware from aluminum to composite or fabric structure. The components that were redesigned included the Lithium hydroxide rack assembly, the middeck pallets, middeck lockers and their associated trays, the middeck accommodations rack, and the tool stowage assembly. The approximate total orbiter weight reduction is 600 to 700 pounds pending the number of pallets flown. All of the above mentioned hardware has been delivered and has supported missions with the exception of the second and third shipset of lockers which will be delivered in early calendar year 2000.

Other miscellaneous modifications completed throughout the year include the delivery of 322 redesigned remote power controllers (RPC's) to replace the existing obsolete RPC's, 100 mission certification of the 17 inch external tank and orbiter disconnect, delivery of the redesigned extravehicular mobility unit battery chargers and the delivery of 13 shipsets of external tank disconnects.

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; full inspection capability by design and demonstrated design reliability through increased fleet leader testing. 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 will expand existing safety margins and reduce operational costs.

The SSME Powerhead is the structural backbone of the engine. The Phase II+ Powerhead has reduced the number of welds, improving producibility and reliability.

The heat exchanger uses the hot 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.

The Large Throat Main Combustion Chamber (LTMCC) first flight was on STS-89 (January 1998) and resulted 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. Consequently, hot gas wall temperatures are significantly reduced increasing chamber life. The LTMCC design also incorporated new fabrication techniques to reduce the number of critical welds and improve the producibility of the chamber.

The development and production of the powerhead, heat exchanger and LTMCC are all being performed under contract with the Rocketdyne division of Boeing Reusable Space Systems.

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 IIA configuration fielding the LTMCC was successfully flown in January 1988 on STS-89. The Block II is scheduled to be flown in FY 2000 and incorporates the alternate high pressure fuel turbopump with the Block IIA design. 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 also 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 have been completed and have been essential to improving the reliability of the Space Shuttle's launch capability.

The Solid Rocket Booster also received several upgrades designed to reduce the expense of recovering and refurbishing the boosters. Those upgrades include a saltwater activated mechanism to release the parachutes (full implementation STS-95), improvements to the parachutes themselves and a modification to the aft skirt brackets.

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 modernization 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.

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50% and will provide the building blocks to support future vehicle control system requirements. The Juno and Redstone phases of the CLCS were delivered in FY 1997. In these phases, the initial integration platform was defined, the engineering platform was installed and the interface with the math models was established. The Thor delivery was completed in FY 1998. During this phase, initial ground data bus interfaces were established and the system software was ported to the production platforms. The Atlas delivery in FY 1999 provided support for the initial applications for the Orbiter Processing Facility, the final applications for the Hypergolic Maintenance Facility, the math model validation, an interface to the Shuttle Avionics Integration Lab (SAIL) and hardware testing for SAIL. The Titan delivery will provide support for completion of development and the start of validation testing for application software used for shuttle orbiter power up testing. The Scout phase of CLCS is planned to support operational use in the Orbiter Processing Facility and development of Pad and launch related application software. The Delta and Saturn phases include the completion of all launch application development, completion of software certification and validation and a complete integrated flow demonstration. Since the FY 1999 Budget, software independent validation and verification (IV&V) performed by Ames Research Center was also added to this project. By the end of FY 2002, Operations Control Room-1 will be fully operational, followed by certification. The first Shuttle launch using the CLCS is scheduled for FY 2002 with full implementation to be completed one year later.

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 replaces 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 2000.

Modernization of the Operational Television System (OTV) is based upon a phased engineering design and implementation strategy, which should enhance and automate the visual surveillance capability at KSC. A key element of the plan includes the design of a camera control system beginning in FY 1996 through FY 2000 which allow the installation of new digital video cameras and their associated elements with minimal impact to operations. Other key elements of the design approach, beginning in FY 1997 are the phased transition to a high bandwidth digital switch, switched digital recording, integrated monitoring stations and a high priority subset of CCD cameras, utilizing a unified control over the entire television environment. Continual efforts have been underway since the project started in FY 1995, in order to phase out existing tube cameras with new CCD cameras, provide functional camera station control and record capability to the new Operations Control Rooms, sustain existing firing room support and replace obsolete switching and recording hardware.

Construction of Facilities (CoF)

FY 1999 CoF funding provided for improvements for facilities at KSC and MAF. At KSC, there are two projects which are both at Launch Complex Pad A - the restoration of the Fixed Support Structure Elevator System and the repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement of bricks in the Flame Trench wall. At MAF, there are two projects Phase III of IV for the rehabilitation of the 480-volt electrical distribution system and Repair Cell E Common solution return and lining.

FY 2000 CoF funding will provide for improvements for facilities at KSC, MAF and SSC. At KSC there are 3 projects which complete the Towway convoy support restoration, repair Pad B Surface and Slope areas and repair the VAB elevators. The SSC project begins the rehabilitation of the A-2 Test Stand for Shuttle Testing and completes the MAF 480V Electrical distribution Rehab. For additional details on these projects, please refer to the Mission Support - Construction of Facilities budget.

BASIS OF FY 2001 FUNDING REQUIREMENT

SHUTTLE OPERATIONS

	FY 1999	FY 2000	FY 2001
	(Thousands of Dollars)		
Orbiter and integration	608,000	698,800	--
Propulsion	1,071,200	1,053,100	--
[External tank]	[363,200]	[355,200]	[--]
[Space shuttle main engine]	[200,000]	[187,500]	[--]
[Reusable solid rocket motor]	[339,000]	[356,700]	[--]
[Solid rocket booster]	[169,000]	[153,700]	[--]
Mission and launch operations	747,500	738,800	--
Total	2,426,700	2,490,700	--

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 is subject to revision as changes to the manifest occur. The FY 1999 reimbursements totaled $35.9 million. The FY 2000 reimbursements are assumed to be $23.2 million. The majority of FY 1999 and FY 2000 reimbursements are due to the Shuttle Radar Topography Mission. These standard service reimbursements offset the total budget for the Space Shuttle and have been assumed in the NASA direct funding requirements identified.

The Space Shuttle operations budget includes sustaining engineering, hardware and software production, logistics, flight and ground operations and flight crew operations for all elements while continuing to pursue environmentally necessary operations and manufacturing improvements. The single, prime contract is the Space Flight Operations Contract (SFOC) held by United Space Alliance comprising one-half of the Operations budget. As development items are completed, additional effort will be transitioned into SFOC.

P.L. 106-74 includes a limitation stipulating that $40 million of the amount provided for Human Space Flight “shall be available to the space shuttle program only for preparations necessary to carry out a life and micro-gravity science mission, to be flown between STS-107 and December 2001.” The amounts earmarked within the FY 2000 Shuttle budget ($40 million) and amounts available in the FY 1999 appropriation for Life and Microgravity Sciences and Applications ($10 million) fall considerably short of the funds needed to conduct a science mission, which ranges $137-166 million. A page on this issue is in the Special Issue Section.

This FY 2001 Request is submitted in a restructured budget format for the Space Shuttle Program. There are several reasons why this new structure is beneficial. First and foremost, as the Program has become more operational in nature and undergone consolidation of its contracts into a single operational contract approach; the budget should reflect the way in which the Program is managed. The Space Shuttle Program is an operational effort, therefore, a budget structure consistent with the nature and maturity of the Program is being implemented. Also, the four major budget elements of Flight Hardware, Ground Operations, Program Integration and Flight Operations are consistent with the Space Flight Operations Contract (SFOC) Work Breakdown Structure. This consistency improves NASA’s ability to account for and reconcile the work accomplished and expenditures.

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; procurement of liquid propellants and gases for launch and base support;
(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) The sustaining engineering associated with flight software and the Orbiter vehicles;
(5) 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

The major contractors for these Orbiter activities are United Space Alliance for operations; and Hamilton Sundstrand for extravehicular mobility unit (EMU) operations.

Other support requirements are also provided for in this budget, including tasks 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.

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 began delivering Super Lightweight Tanks to KSC in support of the performance enhancement goal required by the Space Station in FY 1998. 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 transition of the External Tank contract into Phase II SFOC is currently under review. .

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 Reusable Space Systems, 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.

USA is the prime contractor on the SRB and conducts SRB retrieval, refurbishment and processing at KSC.

The Reusable Solid Rocket Motor (RSRM) project has Thiokol of Brigham City, Utah as the prime contractor for this effort. This activity involves the following:

(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.

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. It also provides for support to landing operations at KSC (primary), Dryden Flight Research Center (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 Shuttle Data Center, which supports Space Shuttle processing as an on-line element of the Checkout and Launch Control 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 include 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 USA. 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). Except for 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 include maintenance and operations of aircraft needed for flight training and crew proficiency requirements.

<u>PROGRAM GOALS</u>

The goal of Space Shuttle Operations is to provide safe, reliable and effective access to space. This budget is based on an average of seven flights annually with a surge capability to nine flights and remains essentially unchanged from previous years. Although FY 1999 had only four flights and six flights are planned for FY 2000, FY 2001 is a nine flight year and includes the third Hubble Space Telescope servicing mission. The flight rate is anticipated to continue at 8 to 9 per year through FY 2004 without any significant increase in this budget. This represents a net increase of one flight during this time period from previous submissions. This manifest supports the Nation's science and technology objectives through scheduled Spacehab and other science missions and commencement of assembly of the International Space Station.

STRATEGY FOR ACHIEVING GOALS

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 was awarded the Space Flight Operations Contract (SFOC) on October 1, 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 USA 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.. The specific schedule for all transitions is currently under review. The reasons for this phased approach are two-fold:

1. The ongoing major development projects 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 ensure 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 operations, is responsible for (a) surveillance and audit to ensure compliance with SFOC requirements and (b) internal NASA functions. Further, NASA retains 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 processes/controls necessary to ensure compliance with contract requirements and to sign a certification of flight readiness (CoFR) to that effect for each flight.

SCHEDULES AND OUTPUTS

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.

	FY 1999		FY 2000		FY 2001
Operations Metrics	Plan	Actual	Plan	Revised	Plan
Number of Space Shuttle Flights	6	4	8	6	[9]
Shuttle Operations Workforce (Prime Contractor		13,800		13,353	[13,045]

(equivalent personnel))					
Space Shuttle Processing Overtime Required	3%	3%	3%	3%	--
Number of Days On-orbit	59	36	80	61	[202]
Number of Primary Payloads Flown	6	4	8	6	[11]

<u>Space Shuttle Missions and Primary Payloads</u>

<u>FY 1999</u>		<u>Plan</u>	<u>Actual/Revised</u>
STS-95/Discovery	Hubble Orbital System Test (HOST)/Spacehab	October 1998	October 1998
STS-88/Endeavour	Space Station #1 (Node 1) (ISS-01-2A)	July 1998	December 1998
STS-93/Columbia	AXAF-Chandra	3rd Qtr FY 1999	July 1999
STS-96/Discovery	Space Station #2 Spacehab Cargo Module (ISS-02-2A.1)	3rd Qtr FY 1999	May 1999
STS-101/Atlantis	Space Station #3 (Spacehab Cargo Module (ISS-03-2A.2)	4th Qtr FY 1999	March 2000
STS-99/Endeavour	Shuttle Radar Topography Mission (SRTM)	4th Qtr FY 1999	January 2000

<u>FY 2000</u>		<u>Plan</u>	<u>Actual/Revised</u>
STS-103/Discovery	Hubble Space Telescope (HST) Servicing Mission 3A	--	December 1999
STS-92/Discovery	Space Station #4 (ITS-Z1) (ISS-04-3A)	1st Qtr FY 2000	June 2000
STS-97/Atlantis	Space Station #5 (PV Module) (ISS-05-4A)	1st Qtr FY 2000	July 2000
STS-98/Endeavour	Space Station #6 (US Lab) (ISS-06-5A)	2nd Qtr FY 2000	August 2000
STS-102/Discovery	Space Station #7 (MPLM-IP-01) (ISS-07-5A.1)	2nd Qtr FY 2000	October 2000
STS-100/Endeavour	Space Station #8 (MPLM-2P-01) (ISS-08-6A)	3rd Qtr FY 2000	November 2000
STS-104/Atlantis	Space Station #9 – Airlock (ISS-09-7A)	4th Qtr FY 2000	February 2001
STS-108/Columbia	Hubble Space Telescope (HST) Servicing Mission 3B	4th Qtr FY 2000	May 2001
STS-105/Atlantis	Space Station #10 (MPLM-IP-02) (ISS-10-7A.1)	4th Qtr FY 2000	March 2001

ACCOMPLISHMENTS AND PLANS

In FY 1999, the Space Shuttle launched four flights successfully including the first ISS assembly mission. This mission (STS-88) joined together the Russia built FCB module with the US built Unity node. Additional flights included one re-supply flight to the ISS and one microgravity research mission, which included the return to space of Senator John Glenn. Lastly, STS-93 successfully deployed another "great observatory" when it launched the Chandra – Advanced X-Ray Astrophysics Facility (AXAF).

The six flights manifested in FY 2000 include the emergency Hubble Space Telescope (HST) Servicing Mission 3A which will replace failing gyros on the HST and the Shuttle Radar Topography Mission (SRTM), a joint DOD/NASA payload to study the earth. The Space Shuttle will also visit the International Space Station four more times, for both assembly and maintenance. The first crew will begin the permanent occupation and presence aboard the ISS.

The Shuttle program has provided launch support for space science missions accommodating universities and industry as a space laboratory and technology research vehicle. Beginning in FY 1999, its primary mission is to support the on-orbit assembly and operations of the International Space Station. The Shuttle is also the only U.S. vehicle that provides human transportation to and from orbit. In FY 1999, 25 crewmembers flew approximately 230 days. In FY 2000, 41 crewmembers are planned to fly approximately 536 days.

BASIS OF FY 2001 FUNDING REQUIREMENT

FLIGHT HARDWARE

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
External Tank Production	[364,300]	[355,700]	349,700
Space Shuttle Main Engine Production	[281,500]	[302,000]	243,300
Space Shuttle Main Engine Test Support	[31,000]	[27,000]	19,900
Reusable Solid Rocket Motor	[341,600]	[358,600]	418,300
Solid Rocket Booster	[170,000]	[153,700]	137,500
Vehicle and EVA	[645,200]	[550,300]	625,800
Flight Hardware Upgrades	[34,800]	[137,300]	211,400
(Safety allocation including upgrades - non-add)			(211,400)
Total	[1,868,400]	[1,884,600]	2,005,900

PROGRAM GOALS

The goal of Flight Hardware programs to produce and maintain the various components of the Space Shuttle vehicles and provide for the upgrades required for safe, reliable and effective access to space.

STRATEGY FOR ACHIEVING GOALS

The Flight Hardware program contain many of the elements previously budgeted in the Space Shuttle Operations budget under Orbiter and Integration and Propulsion Operations, along with work previously budgeted in Safety and Performance Upgrades in Orbiter Improvements and Propulsion Upgrades.

The Flight Hardware program provides for enhancements of the Space Shuttle and produces space components that are not susceptible to damage and maintains core skills and capabilities required modifying and maintaining the Orbiter as a safe and effective transportation and science platform. These activities are provided by Boeing Reusable Space Systems (as a major subcontractor to United Space Alliance (USA)) in two major locations: the Huntington Beach, California facility provides engineering support; the Palmdale, California operation provides Orbiter Maintenance Down Period (OMDP) support as discussed below, as well as manufacturing and testing. 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 Sundstrand.

The Flight Hardware program performs hundreds of modifications throughout the year related to design changes to improve reliability, supportability, or meet new program requirements. These changes are a result of hardware failures or design enhancements identified through ground checkouts or in-flight. Additional Orbiter modifications are approved as the International Space Station development advances and risk mitigation options are identified and implemented. The modifications are implemented either during a standard Orbiter processing flow at Kennedy Space Center in Florida or during Orbiter Maintenance Down Period at Palmdale, California.

Orbiter Maintenance Down Periods (OMDPs) occurs when an 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.

The Main Engine 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 Boeing Reusable Space Systems is responsible for operating three locations that provide engine manufacturing, major overhaul, components 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.

The Marshall Space Flight Center (MSFC) manages engine ground test and flight data evaluation, hardware anomaly reviews and anomaly resolution. The Alternate Turbopump project is also managed by the MSFC under contract with Pratt Whitney of West Palm Beach, FL.

A Safety Allocation is requested in FY 2001 to address Shuttle safety improvements through hardware/software upgrades, personnel, facility, or other investments. This is significant increase over $100 million per year for Shuttle upgrades that was in previous requests. NASA will be conducting an external review to assess how the Safety Allocation funds can most effectively be used to improve the safety of the Space Shuttle. NASA will proceed with the three highest priority upgrade activities, and additional activities may be started pending results of the external review. The three highest priority upgrades are all part of the Flight Hardware budget element, and include two with firm plans: the electric auxiliary power unit (EAPU), and advanced health monitoring for the Space Shuttle main engines (SSME). These two upgrades alone will improve Shuttle safety during ascent from the current 1 in 438 chance of catastrophic failure to 1 in 735. The third of the highest priority upgrades, which is still under study, is for improved avionics in the Shuttle cockpit. This will improve the situational awareness of the crew, and better equip them to handle potential flight anomalies. Additional upgrades will be assessed as part of the external review, and candidates include additional upgrades to the SSME, advanced thrust vector control for the solid rocket boosters, and others. Pending results of the external review, and prior to commitment on specific additional investments, the unspecified Safety Allocation funding is kept under Flight Hardware, although it may shift to other Space Shuttle budget elements after investment decisions are made.

SCHEDULES AND OUTPUTS

Global Positioning System (GPS) - GPS will replace the current TACAN navigational system in the Orbiter navigation system when the military TACAN ground stations will be phased out. The planned readiness date for the Space Shuttle's system is FY 2001.

TACAN Removal Plan: 1st Qtr FY 2002	Select flights will be flown with both systems until the GPS flight hardware is certified.

Orbiter Maintenance Down Periods/Orbiter Major Modification (OMDP/OMM)

Initiate Discovery (OV-103) OMDP Plan: 3rd Qtr FY 2000 Revised: 1st Qtr FY 2002	Conduct routine maintenance and structural inspection. Also, install the MEDS upgrade, hardware for 3-string GPS capability.

Space Shuttle Safety Allocation - New upgrades are being initiated by the Space Shuttle program to help ensure continued safe operations of the Space Shuttle by improving the margin of safety. The dates are planning estimates rather than commitments, as the program is still in an early definitional phase, but all new Space Shuttle safety upgrades will be fully in place on the Shuttle fleet by FY 2005. The Space Shuttle program is in the process of developing detailed project plans.

Electric Auxiliary Power Unit (APU) – Orbiter –Battery powered electric motors will replace turbines powered by hydrazine, a highly flammable and environmentally hazardous fluid. The turbines are used to drive the hydraulic pumps providing control for the orbiter such as engine movement, steering, and braking functions. The upgrade eliminates hydrazine leakage/fire hazards, eliminates turbine overspeed hazards, and reduces toxic materials processing hazards

Electric APU Preliminary Design Review Plan: 3rd Qtr FY 2001	
Electric APU Critical Design Review Plan: 2nd Qtr FY 2002	Completion of Critical Design Review will allow drawings to be released for production to proceed.
Electric APU first flight Plan: 1st Qtr FY 2005	

Space Shuttle Main Engine (SSME) Advanced Health Monitoring (AHM) – Another new safety upgrade, this project entails a suite of instrumentation, software, and computational capabilities for real-time engine assessment, rapid turnaround, and reduction in invasive, manual processing and testing. The system includes vibration monitoring, engine performance monitoring, engine exhaust plume analysis, and overall health analysis. It consists of two phases; Phase I reduces pump failures, Phase II mitigates engine

SSME AHM Phase I first flight
Plan: 3rd Qtr FY 2003

SSME AHM Phase II Preliminary Design Review
Plan: 1st Qtr FY 2002

SSME AHM II Critical Design Review — Completion of Critical Design Review will allow drawings to be released for production to proceed.
Plan: 4th Qtr FY 2002

SSME AHM II first flight
Plan: 1st Qtr FY 2005

Avionics/Cockpit/Safety Implementation – This new safety upgrade improves crew situational awareness and reduces flight crew workload. It provides automated control of complex procedures and increases the level of flight crew autonomy. Functional capabilities include enhanced Caution & Warning (a system to monitor critical instrumentation parameters), abort situation monitoring and trajectory assessment, improved integrated vehicle instrumentation displays, Remote Manipulator System (RMS) safety enhancements for the robotic arm, and rendezvous and proximity operations.

Avionics/Cockpit Preliminary Design Review
Plan: 4th Qtr FY 2001

Avionics/Cockpit Critical Design Review — Completion of Critical Design Review will allow drawings to be released for production to proceed.
Plan: 4th Qtr FY 2002

ACCOMPLISHMENTS AND PLANS

OV-102 has just entered into its major modification and structural inspection at NASA's Palmdale facilities. The major modifications to be performed this period are the installation of the multifunctional electronics display system and the scar for a three-string global positioning system. Additionally, this Orbiter will undergo an extensive wiring inspection with repairs as needed.

To increase the Space Shuttle weight to orbit performance in support of International Space Station flights, the Shuttle Operations program implemented a variety of Orbiter weight-reduction modifications. The project consisted of converting a variety of Orbiter hardware from aluminum to composite or fabric structure. The components that were redesigned included the Lithium hydroxide rack assembly, the middeck pallets, middeck lockers and their associated trays, the middeck accommodations rack, and the tool stowage assembly. The approximate total Orbiter weight reduction is 600 to 700 pounds pending the number of pallets flown. All of the above-mentioned hardware has been delivered and has supported missions with the exception of the second and third shipset of lockers, which will be delivered in early calendar year 2000.

Other miscellaneous modifications completed throughout the year include the delivery of 322 redesigned remote power controllers (RPC's) to replace the existing obsolete RPC's, 100 mission certification of the 17-inch external tank and Orbiter disconnect, delivery of the redesigned extravehicular mobility unit battery chargers and the delivery of 13 shipsets of external tank disconnects.

BASIS OF FY 2001 FUNDING REQUIREMENT

GROUND OPERATIONS

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Launch and Landing Operations..	[548,100]	[506,400]	550,800
Checkout and Launch Control System (CLCS)............................	(50,000)	(39,800)	(40,000)
Ground Operations Upgrades	[1,000]	[8,800]	1,000
(Safety allocation including upgrades - non-add)			(41,000)
Total	[549,100]	[510,300]	551,800

PROGRAM GOALS

The goal of Ground Operations is to provide safe, reliable and effective access to space. This budget is based on an average of seven flights annually with a surge capability to nine flights and remains essentially unchanged from previous years

STRATEGY FOR ACHIEIVING GOALS

The Ground Operations budget was previously funded in Shuttle Operations under Mission and Flight Operations and in Safety and Performance Upgrades in the Flight Operations and Launch Site Equipment upgrades.

The Ground Operations comprises most of the launch site operational facilities at KSC and their required upgrades. 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). The most significant upgrade in this account is the Checkout and Launch Control System (CLCS) at KSC.

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 replaces 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 2000.

Modernization of the Operational Television System (OTV) is based upon a phased engineering design and implementation strategy, which should enhance and automate the visual surveillance capability at KSC. A key element of the plan includes the design of a camera control system beginning in FY 1996 through FY 2000 which allow the installation of new digital video cameras and their associated elements with minimal impact to operations. Other key elements of the design approach, beginning in FY 1997, are the phased transition to a high bandwidth digital switch, switched digital recording, integrated monitoring stations and a high priority subset of CCD cameras, utilizing a unified control over the entire television environment. Continual effort over the life span of the project, FY 1995 to FY 2004, to phase out existing tube cameras with new CCD cameras, provide functional camera station control and record capability to the new Operations Control Rooms, sustain existing firing room support and replace obsolete switching and recording hardware.

The Complex Control System (CCS) is used to monitor and control processing and institutional facilities systems at KSC. The obsolescence of the current CCS makes it difficult and costly to incorporate new measurements and control points as new facilities are built or existing ones are upgraded. CCS infrastructure conversion is scheduled for completion in FY 2001.

Radio Frequency (RF) communications modernization replaces the existing KSC radio communications system with a combination of digital and conventional mobile, portable and fixed stations and associated off-the-shelf equipment. RF communications modernization is scheduled for completion in FY 2001.

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50% and will provide the building blocks to support future vehicle control system requirements.

These upgrades support pre-launch and post-launch processing of the four-Orbiter fleet. Key enhancements funded in launch site equipment include: replacement of 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 modernization 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 equipment upgrades.

The Titan delivery will provide support for completion of development and the start of validation testing for application software used for Shuttle Orbiter power up testing. The Scout phase of CLCS is planned to support operational use in the Orbiter Processing Facility and development of Pad and launch-related application software. The Delta and Saturn phases include the completion of all launch application development, completion of software certification and validation and a complete integrated flow demonstration.

SCHEDULES AND OUTPUTS

First Launch Using CLCS Plan: Under review	Launch the first Shuttle from a CLCS - equipped Launch Control Center.
Complete Migration of CLCS to all Firing Rooms and Simulators Plan: Under review	CLCS fully operational for flight support. This will result in a significant reduction in operating cost, up to 50%, of the current Launch Processing System.

ACCOMPLISHMENTS AND PLANS

The Juno and Redstone phases of the CLCS were delivered in FY 1997. In these phases, the initial integration platform was defined, the engineering platform was installed and the interface with the math models was established. The Thor delivery was completed in FY 1998. During this phase, initial ground data bus interfaces were established and the system software was ported to the production platforms. The Atlas delivery in FY 1999 provided support for the initial applications for the Orbiter Processing Facility, the final applications for the Hypergolic Maintenance Facility, the math model validation, an interface to the Shuttle Avionics Integration Lab (SAIL) and hardware testing for SAIL. Since the FY 1999 Budget, software independent validation and verification (IV&V) performed by Ames Research Center was also added to this project. By the end of FY 2002, Operations Control Room-1 will be fully operational, followed by certification. The first Shuttle launch using the CLCS is scheduled for FY 2002 with full implementation to be completed one year later.

BASIS OF FY 2001 FUNDING REQUIREMENT

FLIGHT OPERATIONS

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Mission Operations	[222,300]	[188,400]	203,500
Flight Crew Operations	[55,400]	[48,300]	62,300
Space and Life Sciences Operations	[6,600]	[7,900]	7,800
Flight Operations Upgrades	[2,500]	[--]	--
Total	[286,800]	[244,600]	273,600

PROGRAM GOALS

The goal of Flights Operations is to provide those services required for safe, reliable and effective access to space and to conduct on-orbit operations. This budget is based on an average of seven flights annually with a surge capability to nine flights and remains essentially unchanged from previous years. Although FY 1999 had only four flights and six flights are planned for FY 2000, FY 2001 is a nine-flight year and includes the third Hubble Space Telescope servicing mission. The flight rate is anticipated to continue at 8 to 9 per year through FY 2004 without any significant increase in this budget. Also, this manifest supports the Nation's science and technology objectives through scheduled Spacehab and other science missions and continuation of assembly of the International Space Station.

STRATEGY FOR ACHIEVING GOALS

The Flight Operations budget was previously funded in Shuttle Operations under Mission and Flight Operations and in Safety and Performance Upgrades in the Flight Operations and Launch Site Equipment upgrades.

Flight Operations include 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 USA. 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). Except for 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 include maintenance and operations of aircraft needed for flight training and crew proficiency requirements.

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.

The major 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 and the T-38 aircraft.

The Flight Operations budget also includes FY 2001 reimbursements that are assumed to be $4.4 million. These standard service reimbursements offset the total budget for the Space Shuttle and have been assumed in the NASA direct funding requirements identified above for the FY 2001 budget request.

SCHEDULES AND OUTPUTS

Space Shuttle Missions and Primary Payloads

FY 2001		Plan	Revised
STS-102/Discovery	Space Station #7 (MPLM-IP-01) (ISS-07-5A.1)	2nd Qtr FY 2000	October 2000
STS-100/Endeavour	Space Station #8 (MPLM-2P-01) (ISS-08-6A)	3rd Qtr FY 2000	November 2000
STS-107/Columbia	Microgravity Research Module/Spacehab	January 2001	
STS-104/Atlantis	Space Station #9 – Airlock (ISS-09-7A)	4th Qtr FY 2000	February 2001
STS-105/Atlantis	Space Station #10 (MPLM-IP-02) (ISS-10-7A.1)	4th Qtr FY 2000	March 2001
STS-106/Endeavour	Space Station #11 – MPLM-2P-02 (ISS-11-UF1)	April 2001	
STS-108/Columbia	Hubble Space Telescope (HST) Servicing Mission 3B	4th Qtr FY 2000	May 2001
STS-109/Atlantis	Space Station #12 (ITS-12-8A)	June 2001	
STS-110/Endeavour	Space Station #13 (ISS-13-UF2)	August 2001	

Operations Metrics	FY 1999 Plan	FY 1999 Actual	FY 2000 Plan	FY 2000 Revised	FY 2001 Plan
Number of Space Shuttle Flights	[6]	[4]	[8]	[6]	9
Shuttle Operations Workforce (Prime Contractor (equivalent personnel))	--	[13,800]	--	[13,353]	13,045
Number of Days On-orbit	[59]	[36]	[80]	[61]	202
Number of Primary Payloads Flown	[6]	[4]	[8]	[7]	11

ACCOMPLISHMENTS AND PLANS

In FY 2001, nine flights are planned to be flown, including seven ISS assembly and servicing missions, a dedicated microgravity research flight and another Hubble Space Telescope Servicing Mission (3B) will be flown.
The Shuttle program has provided launch support for space science missions accommodating universities and industry as a space laboratory and technology research vehicle. The Shuttle is also the only U.S. vehicle that provides human transportation to and from orbit. In FY 2001, 60 crewmembers are planned to fly approximately 1,280 days on-orbit, including time spent by Americans aboard the International Space Station.

BASIS OF FY 2001 FUNDING REQUIREMENT

PROGRAM INTEGRATION

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Shuttle Integration	[145,300]	[178,300]	201,500
Shuttle Integration Upgrades	[6,700]	[900]	4,000
Program Management Support	[128,500]	[149,800]	113,300
Facilities Construction	[13,500]	[11,000]	15,600
(Safety allocation including upgrades - non-add)	(--)	(--)	(4,000)
Total	[294,000]	[340,000]	334,400

PROGRAM GOALS

The goal of Program Integration is to ensure the integration of the various Shuttle elements occurs successfully. Program Integration performs hundreds of modifications throughout the year related to design changes to improve reliability, supportability, or meet new program requirements. These changes are a result of hardware failures or design enhancements identified through ground checkouts or in-flight.

STRATEGY FOR ACHIEVING GOALS

The Program Integration budget was previously budgeted predominately in the Space Shuttle Operations budget under Orbiter and Integration along with the Construction of Facilities line in the Safety and Performance Upgrades budget, also some small residual funding came from other areas.

The Program Integration portion of the Space Operations budget includes funds for. analysis, management, and the SRM&QA function and are performed here for the entire Space Shuttle Program. In addition, this area includes funds for the infrastructure, taxes and directly funded construction of facilities projects.

Construction of Facilities (CofF) funding for Space Shuttle projects is provided in this budget to refurbish, modify, reclaim, 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 Shuttle Operations.

SCHEDULES AND OUTPUTS

Complete Pad A Surface and Slope Restoration at LC-39 Plan: 1st Qtr. FY 01	This project provides for repair of the Pad A surface concrete, pad slopes, and the crawlerway grid path. Follow on project required, scope too extensive for budget and time allotted.
Rehabilitation of 480V Electrical Distribution System at MAF	External Tank manufacturing building Rehabilitation of the 480V Electrical Distribution System is a 4 phase project. Each phase will be implemented in the main manufacturing areas of building 103. Project Phasing and scope for each phase:
Complete Phase III Plan: 1st Qtr. FY 2001	Phase III, Substations Nos. 17A/17B will replace the core system, Transformers and switch gear, breakers and oil switches. Include some down stream cable, cable tray, and panel upgrades.
Complete Phase IV Plan: 2nd Qtr. FY 2001	Phase IV, Substations Nos., 7B, 4 & 5 – core system, transformers and switchgear, breakers and oil switches.
Complete Restoration of Pad A PCR Wall and Ceiling Integrity at Launch Complex (LC)-39 Plan: 1st Qtr. FY 01	This project provides for repair and replacement of damaged Payload Change Out Room (PCR) wall panels (Sides 1, 2, 3, & 4), replacement or elimination of deteriorated and leaking access doors, and other needed replacement and restoration. The modification will eliminate degrading flexducts and filter housings, improve pressurization of the PCR, provide an even distribution of airflow, and provide safe personnel access for maintenance and repair.

ACCOMPLISHMENTS AND PLANS

FY 2001 CoF funding will provide for improvements for facilities at JSC, KSC, MAF and SSC. At KSC there are 3 projects which complete the refurbishment of Pad B Payload Change Room (Wall and Ceiling), phase 1 of restoring low volt power system (Pad A and B), and the rehabilitation of high pressure distribution piping system (LC-39A/B). The JSC project repairs the roofs at Palmdale, Building 150. The SSC project modifies the A-2 Test Stand for Shuttle Testing. The MAF project repairs and upgrades the main electrical distribution system servicing the Vertical Assembly Building (110) and the Mix Room Building (130). For additional details on these projects, please refer to the Mission Support - Construction of Facilities budget.

To supplement the network of management reviews and government oversight functions, NASA continues to seek specific objective measurements of overall performance of the Shuttle Operations program. In order to permit rapid review by the program managers, the Shuttle program has devised a series of "stoplight" metrics. The metrics are devised 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, Shuttle processing 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 liftoff attempts per mission and characterizing any delays or scrubs as to technical, weather or operational-related reasons.