INTERNATIONAL SPACE STATION*

FISCAL YEAR 2000 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT | **SPACE STATION**

SUMMARY OF RESOURCES REQUIREMENTS**

	FY 1998 OPLAN 9/29/98	FY 1999 OPLAN 12/22/98	FY 2000 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Vehicle	1,604,800	1,034,000	890,100	ISS 1-5
Operations Capability	500,200	685,900	850,200	ISS 1-17
[Construction of Facilities included]	[--]	[1,200]	[--]	
Research	226,300	336,500	394,400	ISS 1-25
Russian Program Assurance	[110,000]	248,300	200,000	ISS 1-39
Crew Return Vehicle	--	--	148,000	ISS 1-45
Total	2,331,300	2,304,700	2,482,700	

Distribution of Program Amount by Installation

	FY 1998	FY 1999	FY 2000
Johnson Space Center	2,034,100	1,876,000	2,011,700
Kennedy Space Center	94,100	108,300	114,100
Marshall Space Flight Center	142,600	222,000	215,000
Ames Research Center	20,200	41,000	61,100
Langley Research Center	7,000	4,300	2,900
Glenn Research Center	30,600	30,500	49,900
Goddard Space Flight Center	700	--	--
Jet Propulsion Laboratory	600	5,600	11,000
Headquarters	1,400	17,000	17,000
Total	2,331,300	2,304,700	2,482,700

* The Space Station was funded in the Human Space Flight appropriation account in FY 1998 and FY 1999. The FY 1999 appropriations act directed NASA to submit the International Space Station as a separate appropriation account in the FY 2000 budget.

** Summary adjusted to reflect the effect of restructured budget in FY 2000, and prospective reallocations to the FY 1999 operating plan. The December 22, 1998 operating plan includes $53 million for Russian Program Assurance (RPA) for FY 1999. This budget assumes additional reallocations of $195.3 million from Vehicle to RPA in FY 1999.

PROGRAM GOALS

The goal of the International Space Station (ISS) is to support activities requiring the unique attributes of humans in space and establish a permanent human presence in Earth orbit. It provides a long-duration habitable laboratory for science and research activities which allow investigation of the limits of human performance, vastly expand human experience in living and working in space, and provide the capability to encourage and enable commercial development of space. The ISS will provide a capability to perform unique, long duration, space-based research in cell and developmental biology, plant biology, human physiology, fluid physics, combustion science, materials science and fundamental physics. ISS will also provide a unique platform for making observations of the Earth's surface and atmosphere, the sun, and other astronomical objects. The experience and dramatic results obtained from the use of the ISS will guide the future direction of the Human Exploration and Development of Space Enterprise, one of NASA's key strategic areas. The International Space Station is key to NASA's ability to fulfill its mission to explore, use, and enable the development of space for human enterprise.

STRATEGY FOR ACHIEVING GOALS

The ISS will be a laboratory in low Earth orbit on which American and international crews will conduct unique scientific and technological investigations in a microgravity environment. Establishing a permanent human presence in space, which the ISS makes possible, remains one of NASA's highest priorities. The Space Station is unique because it will provide the world with an unparalleled laboratory and habitable international outpost in space. The schedule for the current design emphasizes an early permanent crew capability that provides an advanced research facility for use by international crews for extended duration missions. Therefore, early in the on-orbit assembly of the program, the Space Station will provide the capability to stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge.

The ISS is the culmination of the space station “Freedom” redesign work begun in FY 1993 to meet the President's goal to reduce program costs while still providing significant research capabilities.

The baseline program content includes ISS vehicle development, operations capability, and research, and has been expanded to include ongoing contingency activities in Russian program assurance, and development of a crew return vehicle. Extensive coordination with the user community is well underway, with payload facilities development and research and technology activities being coordinated with the Office of Life and Microgravity Sciences and Applications (OLMSA), the Office of Earth Science

(OES) and the Office of Space Science (OSS). A plan for transition of utilization responsibilities back to the research offices once payload facilities are operational will be prepared later this year.

International participation in the Space Station program was initiated in 1984 with invitations issued by President Reagan to Europe, Japan and Canada. With the U.S. playing the lead role, the international partnership invited Russia to participate in the program in 1993. As a result, Space Station cooperating agencies now include NASA, the Russian Space Agency (RSA), the Canadian Space Agency (CSA), the European Space Agency (ESA), and the National Space Development Agency of Japan (NASDA). International participation in the program has significantly enhanced the capabilities of the ISS. Through FY 1998, the CSA, ESA and NASDA have invested nearly $4.5 billion for design and development, and anticipate a total expenditure of $10 billion. In accordance with the terms of the agreements, the U.S. and our international partners will share the total available resources and the common costs for operations. The ISS represents an unprecedented level of international cooperation.

Additionally, there are several bilateral agreements between NASA and other international agencies. An agreement with ESA provides early research opportunities to them in exchange for provision of research equipment to the U.S. Another agreement with ESA provides the U.S. with Nodes 2 and 3 as an offset for the Shuttle launch for the Columbus Orbital Facility (COF). A similar Agreement in Principle with NASDA provides a Centrifuge, Centrifuge Accommodation Module (CAM), and Life Sciences Glovebox as an offset for the Shuttle launch of the Japanese Experiment Module (JEM). NASA and the Italian Space Agency have an agreement for Italy's provision of three Multi-Purpose Logistics Modules (MPLMs) in exchange for research opportunities. The Brazilian Space Agency (AEB) has become a participant in the U.S. ISS program as well, by helping fulfill a portion of U.S. obligations to the ISS program in exchange for access to the U.S. share of ISS resources.

Development of the Space Station program is being conducted in a phased approach. The initial phase, which was successfully concluded in 1998, included nine Shuttle-Mir docking missions. The goals of this initial phase were to develop and demonstrate joint mission procedures with Russia, to gain valuable experience to reduce technical risk during International Space Station construction, and to provide early opportunities for extended scientific research.

The next phase of the program began with the launch of the U.S.-owned/Russian-launched Zarya propulsion module in November 1998, and concludes with the launch of the airlock on flight 7A. Permanent crew capability for three persons, and launch of the first crew to orbit is scheduled to occur in the second quarter of FY 2000, with the launch of the first Russian Soyuz spacecraft to ISS. Microgravity capability will be available in April 2000, with the outfitting of the U.S. laboratory. At completion of this phase in the fourth quarter of FY 2000, the Station configuration will include Unity (the first U.S. node), Discovery (the U.S. laboratory), pressurized mating adapters, power, airlock and multi-purpose logistics module (MPLM); Zarya, the Russian service module, and a Soyuz capsule; and the Space Station remote manipulator system (SSRMS) provided by Canada.

By the end of FY 2002 the Station configuration will include the U.S. Laboratory, the second U.S. node, truss segments, three solar arrays, the Japanese Experimental Module (JEM), and resupply/support vehicles. By the end of FY 2003, planned activities include the delivery to orbit of the two Russian research modules, the third U.S. Node, and the Cupola. By the end of FY 2004 the Station configuration will include the Columbus Orbital Facility (COF, ESA's pressurized module), the Crew Return Vehicle (CRV), the fourth Solar Array, the Centrifuge Accommodation Module (CAM)/Centrifuge and the habitation module. Delivery of the crew return vehicle and the final outfitting flight will mark the beginning of the permanent 6-member crew capability. Delivery of the habitation module will signal the initiation of the permanent 7-member crew capability. Routine logistics module launches to the Space Station will continue over the remaining life of the Station.

BASIS OF FY 2000 FUNDING REQUIREMENT

SPACE STATION VEHICLE

	FY 1998	FY 1999	FY 2000
		(Thousands of Dollars)	
Flight hardware	1,461,000	853,200	748,700
Test, manufacturing and assembly	97,400	142,600	119,900
Transportation support	45,500	38,200	21,500
Flight technology demonstrations	900	--	--
Total	1,604,800	1,034,000	890,100

PROGRAM GOALS

Vehicle development of the International Space Station (ISS) will provide an on-orbit, habitable laboratory for science and research activities, including flight and test hardware and software, flight demonstrations for risk mitigation, and facility construction, shuttle hardware and integration for assembly and operation of the station, mission planning, and integration of Space Station systems.

STRATEGY FOR ACHIEVING GOALS

Responsibility for providing Space Station elements is shared among the U.S. and our international partners from Russia, Europe, Japan, and Canada. The U.S. elements include three nodes, a laboratory module, airlock, truss segments, four photovoltaic arrays, a habitation module, three pressurized mating adapters, unpressurized logistics carriers, and a cupola. Various systems are also being developed by the U.S., including thermal control, life support, navigation and propulsion, command and data handling, power systems, and internal audio/video. The U.S. funded elements also include the Zarya propulsion module provided by a Russian firm under the Boeing prime contract. Other U.S. elements being provided through bilateral agreements include the pressurized logistics modules provided by the Italian Space Agency, Nodes 2 and 3 provided by ESA, and the centrifuge accommodation module (CAM) and centrifuge provided by the Japanese.

Canada, member states of the European Space Agency (ESA), Japan, and Russia are also responsible for providing a number of ISS elements. Laboratory modules will be provided by the Japanese, ESA, and Russia. Canada will provide a remote manipulator system, vital for assembly of the station. The Russian Space Agency (RSA) is also providing significant ISS infrastructure elements including the Service Module (SM), science power platform, Soyuz crew transfer vehicle, Progress resupply vehicles, and universal docking modules.

The Boeing Company is the prime contractor for the design and development of U.S. elements of the International Space Station. It also has prime responsibility for integration of all U.S. and International Partner contributions and for assembly of the ISS. At their Huntington Beach site location (formerly McDonnell Douglas), Boeing is developing and building the integrated truss segments that support station elements and house essential systems, including central power distribution, thermal distribution and attitude control equipment. Other Boeing locations are also supporting the flight hardware build to mitigate capability shortfalls at Huntington Beach. Additionally major components of the communications and data handling, thermal control, and the guidance, navigation and control subsystems are being developed at Huntington Beach.

U.S. pressurized modules are being developed by Boeing at their Huntsville site location, and by ESA. The second flight to ISS, successfully conducted in December 1998, deployed Unity, a pressurized node which contains four radial and two axial berthing ports. Attached to the Node were two pressurized mating adapters (PMAs), which will serve as docking locations for the delivery of the U.S. Laboratory Module and the Multi-Purpose Pressurized Logistics Module. Under a bilateral agreement, ESA is providing Nodes 2 and 3 to the U.S. Node 2 is currently manifested for flight during the third quarter of FY 2002, the Cupola is manifested for flight during the third quarter of FY 2003, and Node 3 is manifested for flight during the fourth quarter of FY 2003. The final U.S. pressurized volume is the Habitation Module that will contain the galley, wardroom, waste management, water processing and other crew support functions necessary for human operations.

The power truss segments and power system, essential to the Station's housekeeping operations and scientific payloads, are being built by Boeing at their Canoga Park location (formerly Rocketdyne Division, Rockwell International). Four photovoltaic elements, each containing a mast, rotary joint, radiator, arrays, and associated power storage and conditioning elements comprise the power system.

The vehicle program also includes test, manufacturing and assembly support for critical NASA center activities and institutional support. These “in-line” products and services include: test capabilities; the provision of government-furnished equipment (GFE), including flight crew systems, environment control and life support systems, communications and tracking, and extravehicular activity (EVA) equipment; and, engineering analyses. As such, they support the work of the prime contractor, its major subcontractors and NASA system engineering and integration efforts.

Transportation support provides those activities that allow the Space Shuttle to dock with the Space Station. This budget supports development and procurement of two external Shuttle airlocks, and upgrade of a third airlock to full system capability, which were required for docking the Space Shuttle with the Russian Mir as well as for use with the Space Station. Other items in this budget include: the Shuttle Remote Manipulator System (RMS) and Space Shuttle mission training facility upgrades; development of a UHF communications system and a laser sensor; procurement of an operational space vision system; procurement of three docking mechanisms and Space Station docking rings; EVA/Extravehicular Mobility Units (EMU) services and hardware; and integration costs to provide analyses and model development.

Flight technology demonstrations were flown during Phase I, utilizing the Space Shuttle flights to the Russian Mir Space Station, in order to benefit the future operational phases of the ISS program. These demonstrations focused on areas of joint NASA/RSA developments where levels of technical or programmatic risk warranted additional verification, including: life support, the data processing system, automatic rendezvous and docking, vibration isolation in a microgravity environment, assembly and maintenance, loads and dynamics, contamination, radiation environment, micrometeoroid/orbital debris, and operational techniques development.

SCHEDULE & OUTPUTS

Completed Incremental Design Review (IDR)
Performed Stage Integration Reviews (SIR)

A series of incremental, cumulative reviews throughout the design phase to assure that system level requirements are properly implemented in the design, have tractability, and that hardware and software can be integrated to support staged assembly and operation. IDR #1 performed these functions for flights 1A/R through 6A. Subsequently, IDR #2 assessed design progress for flights 1A/R through 7A. IDR#2B assessed the entire Space Station assembly sequence.

IDRs have been replaced by Stage Integration Reviews (SIR), a more classical critical design review approach on a stage-by-stage basis which review groupings of flights with assembly hardware and functionality/performance linkages across the stage.

- Performed SIR 1 for flights through 2A (4th Qtr FY 1997)
- Performed SIR 2 for flights through 4A (1st Qtr FY 1998)
- Performed SIR 3 for flights through 6A (2nd Qtr FY 1998)
- Perform SIR 4 for flights through 4R (1st Qtr FY 1999)
- Perform SIR 5 for flights through UF-2 (1st Qtr FY 2000)

Prime Development Activity

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

Flight 1A/R:
Zarya (FGB Energy Block)
(First Element Launch)
(Proton Launch Vehicle)
Planned (Rev B): Nov. 1997
Revised (Rev D Mod): Nov.1998
Completed November 1998

Self-powered, active vehicle; provides attitude control through early assembly stages; provides fuel storage capability after the service module is attached; provides rendezvous and docking capability.

- Completed factory ground testing of first flight unit (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1998)
- Completed flight software (slip from 3rd Qtr FY 1997 to 1st Qtr FY1998)
- Delivered FGB flight article to Baikanour (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1998)
- Installed solar arrays in FGB flight article (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998)
- Removed Zarya from storage and complete deconservation (1st Qtr FY 1999)
- Mated FGB to Launch Vehicle (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999)
- On-Orbit checkout, Service Module docking, fuel transfer (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999)

- Launch of the Zarya (1st Qtr FY 1999)

Flight 2A: Unity (Node 1), Pressurized Mating Adapters (PMA-1, PMA-2) Planned (Rev B): Dec. 1997 Revised (Rev D Mod): Dec.1998 Completed December 1998	Initial U.S. pressurized element, launched with PMA-1, PMA-2, and 1 stowage rack; PMA-1 provides the interfaces between U.S. and Russian elements; PMA-2 provides a Space Shuttle docking location. • Completed Node STA static flight loads testing (slip from 4th Qtr FY 1997 to 1st Qtr FY 1998) • Completed mating of PMA-1 to Node (1st Qtr FY 1998) • Completed flight 2A Cargo Element Integration and Test (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998) • Completed mating of PMA-2 to Node (3rd Qtr FY 1998) • Space Shuttle Payload Integration and Test (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999) • Launch of Unity (flight 2A) (1st Qtr FY 1999)
Flight 2A.1 Logistics Planned (Rev C): Dec. 1998 Revised (Rev D Mod): 3rd Qtr FY 1999	Double Spacehab flight for logistics/resupply during early assembly; • Station Cargo Integration Review (SCIR) (2nd Qtr FY 1998) • Flight Operations Review (FOR) (2nd Qtr FY 1999) • Hardware on dock at KSC (2nd Qtr FY 1999) • Begin integration of critical spares into Spacehab Module (2nd Qtr FY 1999) • Delivery of Strela Cargo Crane to Integrated Cargo Carrier integration (2nd Qtr FY 1999) • Launch of flight 2A.1 (3rd Qtr FY 1999)
Flight 2A.2 Logistics Planned: 4th Qtr FY 1999	Double Spacehab flight for logistics during early assembly; equipment to outfit the service module. *This flight is currently in the planning stages.*
Flight 3A: Z1 Truss Segment, Control Moment Gyros (CMGs), PMA-3, KU-Band Planned (Rev B): July 1998 Revised (Rev D Mod): 1st Qtr FY 2000	Z1 Truss allows temporary installation of the P6 photovoltaic module to Node 1 for early U.S. based power; KU-band and CMGs support early science capability; PMA-3 provides a Space Shuttle docking location for the lab installation on flight 5A. • Completed CMG qualification and flight testing (2nd Qtr FY 1998) • Began assembly of 3A flight model DDCUs (slip from 1st Qtr FY 1997 to 1st Qtr FY 1998) • Z1 structure qualification completed (slip from 2nd Qtr FY 1997 to 3rd Qtr FY 1998) • Z1 modal and static qualification tests complete (slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998) • PMA-3 on-dock at KSC (Slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998) • KU-Band on dock at KSC (2nd Qtr FY 1998)

- S-Band on dock at KSC (3rd Qtr FY 1998)
- Z1 final assembly and test (4th Qtr FY 1998)

Flight 4A:
P6 Truss segment, Photovoltaic Array, Thermal Control System (TCS) Radiators, S-Band Equipment
Planned (Rev B): Nov. 1998
Revised (Rev D Mod): 1st Qtr FY 2000

This flight provides the first U.S. solar power via solar arrays and batteries, cooling capability and S-Band system activation

- BGA to P6 Integ (3rd Qtr FY 1998)
- IEA/Long Spacer ready for integration and test (4th Qtr FY 1998)
- Z1/P6 on dock KSC for MEIT (4th Qtr FY 1998)
- Qualification and flight model radiators delivered (1st Qtr FY 1999)
- Solar Arrays on-dock KSC (2nd Qtr FY 1999)
- Launch flight 4A (1st Qtr FY 2000)

Flight 5A:
U.S. Laboratory,
5 Lab System Racks
Planned (Rev B): Dec. 1998
Revised (Rev D Mod): 2nd Qtr FY 2000

Establishes initial U.S. user capability; launches with 4 system racks preintegrated; KU-band and CMGs are activated.

- Complete flight 5A Stage Integration Review (slip from 4th Qtr FY 1997 to 3rd Qtr FY 1998)
- Install 5A/6A Racks in Lab for testing (3rd Qtr FY 1998)
- Complete lab racks, crew systems, closeouts, and hatch installation (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999)
- Lab on dock at KSC (1st Qtr FY 1999)
- Deliver Command and Control and Guidance Navigation and Control Software to Lab (2nd Qtr FY 1999)
- Launch of flight 5A (2nd Qtr FY 2000)

Flight 5A.1:
MPLM flight module-1,
6 Lab System Racks,
1 Payload Rack
Planned: 2nd Qtr FY 2000

Continues the outfitting of the U.S. Lab, with the launch of 6 system racks. This flight also represents the first use of science with the launch of the Human Research Facility (HRF) rack. It is also the first use of the Multi-Purpose Logistics Module (MPLM).

- Complete MPLM Integration and Test (4th Qtr FY 1998)
- MPLM on-dock at KSC (4th Qtr FY 1998)
- Lab on dock at KSC (1st Qtr FY 1999)
- Complete MPLM portion of MEIT (2nd Qtr FY 1999)
- Integration of HRF Sub-racks into the HRF rack (3rd Qtr FY 1999
- HRF rack on-dock at KSC (1st Qtr FY 2000)

Flight 6A:
MPLM flight module-2, Canadian Remote Manipulator System, UHF
Planned (Rev B): January 1999
Revised (Rev D Mod): 3rd Qtr FY 2000

Continues U.S. lab outfitting with delivery of 2 stowage and 2 EXPRESS payload racks; UHF antenna provides space-to-space communication capability for U.S. based EVA; manifests Canadian SSRMS needed to perform assembly operations on later flights.

- Complete Stage Assessment Integration Review (slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998)
- Complete weld of MPLM FM2 Structure (3rd Qtr FY 1998)
- SSRMS and RWS Software complete (1st Qtr FY 1999)
- SSRMS On-dock KSC (2nd Qtr FY 1999)
- Begin integration of Spacelab Logistics Pallet (SLP) Cargo Element (slip from 2nd Qtr FY 1998 to 3rd Qtr FY 1999)
- Complete Integration and Test of MPLM FM2 (3rd Qtr 1999)
- MPLM FM2 On-dock KSC (3rd Qtr 1999)
- MEIT I Complete (3rd Qtr FY 1999)
- Launch of flight 6A (3rd Qtr FY 2000)

Flight 7A:
Airlock, HP Gas
Plan (Rev B): April 1999.
Actual (Rev D Mod): 4th Qtr FY 2000

Launches the airlock and installs it on orbit. The addition of the airlock permits ISS-based EVA to be performed without loss of environmental consumables such as air.

- Began Airlock Integration/A&CO (4th Qtr FY 1998)
- Element level testing complete (3rd Qtr FY 1999)
- Airlock on dock at KSC (3rd Qtr FY 1999)
- Complete SLP integration (3rd Qtr FY 1999)
- Launch flight 7A (4th Qtr FY 2000)

Flight 7A.1
MPLM, SLP pallet
Planned (Rev B): Nov. 1999
Revised (Rev D Mod): 4th Qtr FY 2000

Logistics and utilization mission delivering resupply/return stowage racks resupply stowage platforms, and two EXPRESS payload racks. This flight will carry critical spares as well as various resupply items.

- Turnover of EXPRESS racks to KSC (2nd Qtr FY 2000)
- Launch of MPLM FM1 (re-use) on flight 7A.1 (4th Qtr FY 2000)

Flight 8A:
S0 Truss, Mobile Transporter,
Plan (Rev B): June 1999
Revised (Rev D Mod): 2nd Qtr FY 2001

S0 is the truss segment that provides attachment and umbilicals between pressurized elements and truss mounted distributed systems/utilities. Mobile Transporter provides SSRMS translation capability along the truss.

- Complete S0 STA fabrication, assembly, and outfitting (1st Qtr FY 1999)

- Complete S0 STA structural testing (4th Qtr FY 1999)
- Complete S0 flight fabrication, assembly, and outfitting (3rd Qtr FY 1999)
- S0 on dock at KSC (3rd Qtr FY 1999)
- Complete S0 integrated testing (1st Qtr FY 2000)
- Complete Mobile Transporter flight article (2nd Qtr FY 1999)

Flight 9A:
S1 Truss, CETA Cart
Plan (Rev B): September 1999
Revised (Rev D Mod): 3rd Qtr FY 2001

S1 truss provides permanent active thermal control capability. Crew and Equipment Translation Aid (CETA) cart provides EVA crew translation capability along the truss.

- Complete second S-band string (3rd Qtr FY 1998)
- Radiators complete for S1 Integration (3rd Qtr FY 1999)
- Complete S1 STA fabrication, assembly, and outfitting (2nd Qtr FY 1999)
- Complete S1 STA testing (2nd Qtr FY 2000)
- Complete S1 flight fabrication, assembly, and outfitting (4th Qtr FY 1999)
- S1 on dock at KSC (4th Qtr FY 1999)
- Complete S1 integrated testing (1st Qtr FY 2000)

Non-Prime Development Activity

Global Positioning System (GPS)

Provides autonomous, real-time determination of Space Station's position, velocity, and attitude

- Delivered GPS Antenna Assembly (4th Qtr FY 1997)
- Deliver GPS Receiver/Processor (slip from 3rd Qtr FY 1997 to 1st Qtr FY 1999)

Extra-Vehicular Activity System

Provides Government Furnished Equipment (GFE), EVA unique tools, Orlan SAFER (Russian space suit), and EVA support equipment for the Space Station. Provides EVA development and verification testing. Provides for operation of the WETF/NBL and the maintenance of neutral buoyancy mockups to support Station EVA development activities.

- Deliver Crew Equipment Transfer Aid (CETA) Cart proto-flight unit (slip from 1st Qtr FY 1997 to 4th Qtr FY 1999)
- Deliver EVA Tool Storage Device (ETSD) for CETA Cart (1st Qtr FY 1998)
- Deliver ETSD for airlock (1st Qtr FY 1998)
- Deliver 1st 3 canisters for the Regenerable CO_2 System (2nd Qtr FY 1998)
- Deliver 1st Flight Regenerator for the Regenerable CO_2 System (3rd Qtr FY 1998)
- ORU Transfer Device (OTD) flight unit complete (1st Qtr FY 1999)

Flight Crew Systems	Provides flight and training hardware and provisions for food and food packaging development; housekeeping management; portable breathing apparatus; restraints and mobility aids; tools diagnostic equipment and portable illumination kit. • Completed 6A Operations and Personal Equipment CDR (1st Qtr FY 1997) • Delivered Restraints and Mobility Aids (1st Qtr FY 1997) • Completed CDR for portable illumination (2nd Qtr FY 1997) • Complete Stowage Tray Restraint CDR (slip from 2nd Qtr FY 1997 to TBD) • Complete production of tools and diagnostic flight hardware kit (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998) • Complete Personal Hygiene Kit PRR Preliminary/Program Requirements Review (2nd Qtr FY 1998) • Deliver Maintenance Workstation Kit, Portable Illumination, and Housekeeping Kit (4th Qtr FY 1998)
Airlock Service And Performance Checkout Unit	Provides flight servicing, performance unit, and certification unit, Russian space suit support hardware interface definition and documentation, test plans and reports, mockups, and thermal analysis. • Deliver certification unit hardware to airlock test article (Slip from 2nd Qtr FY 1997 to 3rd Qtr FY 1998) • Complete qualification unit testing and flight unit acceptance testing (slip from 4th Qtr FY 1997 to 3rd Qtr FY 1999)

ACCOMPLISHMENTS AND PLANS

FY 1998 activities focused on the buildup of ISS elements required for Phase 2/3 assembly of the International Space Station. These activities included:

- Modifications to the Zarya spacecraft, implemented under the U.S. Russian Cooperation and Program Assurance budget to accommodate SM uncertainties, have been completed. Testing on the Zarya was completed in May 1998, and it was in storage at the Baikonur launch site until August. The Zarya launched November 20th, 1998.

- The flight 2A activities in FY 1998 included Common Berthing Module acceptance testing, Cargo Element integration, and the completion of Space Station Processing Facility integration. Flight 2A launched December 4th, 1998.

- Flight 2A.1 was added to the assembly sequence in early FY 1998. Two elements, a Spacehab double module and an ICC (Integrated Cargo Carrier), are required to transport certain Spares hardware and the Russian Strela (cargo crane). Key 2A.1 activities in FY 1998 include a final manifest decision on the Russian Strela, as well as the manufacture and test of the spares hardware scheduled to fly on this flight.

- Flight 2A.2 was added to the assembly sequence in early FY 1999. This flight carries the same two elements, a Spacehab double module and an ICC as flight 2A.1. The hardware to be launched on this flight is still under review.

- In preparation for flight 3A, fabrication, assembly and qualification testing of the Z1 truss segment was completed. The Z1 truss segment has completed Z1/P6 integration testing. PMA-3 outfit and test was completed in mid-1998. Other major accomplishments in FY 1998 included the completion of qualification testing and the delivery of S-Band and Ku-Band flight hardware for Z1 truss integration. Set up for Multi-Element Integration Testing (MEIT) - Test Condition One began in the last quarter of FY 1998.

- Flight 4A launches the Integrated Equipment Assembly (IEA), Photovoltaic (PV) Array, Early External Active Thermal Control System (EEATCS), and the P6 truss segment. This flight provides the first U.S. solar power via solar arrays and batteries, cooling capability and S-Band system activation. Activities for flight 4A in FY 1998 included the completion of the fabrication and assembly of the P6 IEA. Outfitting and Z1/P6 integration testing was completed in the fourth quarter of FY 1998. Flight deliveries of the electrical ORUs have arrived at KSC for integration into the IEA.

- Structural test article testing and standoff/endcone installation for the U. S. Lab have been completed. 5A/5A.1 racks have been installed, and remaining Lab qualification hardware/software integration testing is continuing. The configured Lab Module arrived on-dock at KSC on November 16th, 1998, in preparation for MEIT that begins in March 1999.

- Flight 5A.1 was added to the assembly sequence in early FY 1999. This flight represents the first use of the Multi-Purpose Logistics Module (MPLM). The MPLM for flight 5A.1 has completed its integration and testing and has been delivered to KSC in preparation for MEIT. The Human Research Facility (HRF) Rack, which represents the first utilization for the ISS for science/experiments, is currently in assembly and is scheduled to be at KSC in the first quarter of FY 2000.

- The MPLM used on flight 6A is the second flight unit to be built. The structure for this unit is scheduled to be completed early in FY 1999. The SSRMS, which also flies on flight 6A, completed its acceptance review and is scheduled for delivery to KSC in the Spring of 1999. There are two EXPRESS payload racks scheduled to be launched on flight 6A. One of these racks is the first use of an Active Rack Isolation System (ARIS) EXPRESS rack. Both of the EXPRESS racks began their sub-rack integration and verification in FY 1998.

- The airlock, which flies on flight 7A, completed its Structural Static Test in early 1998. The Structural Modal Test was completed in May 1998. Airlock assembly and checkout began in the 4th Qtr of FY 1998. The airlock system racks were completed in FY 1998 and are ready to be integrated into the airlock for element level testing.

- Flight 7A.1 involves the re-use of MPLM FM1 to transport spares and resupply items as well as two additional EXPRESS racks. This flight is currently under review.

- Flight UF-1 also involves the re-use of a MPLM (FM2) to transport the Minus Eighty Degree Laboratory Freezer (MELFI) and the Microgravity Sciences Glovebox. The Spares Warehouse, which was added in FY 1998 to provide on-orbit stowage for critical spares, will also be transported.

- Primary Structure assembly for integrated truss structure S0, which is launched with flight 8A, was completed, and secondary structure assembly was started in early FY 1998. Effort in FY 1998 was focused on the sub-systems that are integrated into the S0 element. Qualification testing for the Mobile Transporter has started and is scheduled to complete in the second quarter of FY 1999.

- Flight UF-2 involves the use of an MPLM to transport the fifth EXPRESS Rack and Window Observation Research Facility (WORF). The Mobile Base System (MBS), which is used with the MT to provide a base for the arm, also rides in the Shuttle Cargo Bay. This flight is currently under review.

FY 1999 activities focused on the buildup of ISS elements required for Phase 2/3 assembly of the International Space Station. These activities included:

- The major program focus will be integrating and testing flight hardware and software to support the initial launches of the ISS. FY 1999 assembly activities began with the successful launch of the U.S. owned/Russian launched functional cargo block (Zarya) in November of 1998. Zarya is a self-sufficient orbital vehicle that will provide initial capabilities for propulsion, guidance, communication, electrical power and thermal control systems.

- The second assembly flight, flight 2A, launched Unity (Node 1), 1 stowage rack, and two pressurized mating adapters (PMA-1 & PMA-2) on the Space Shuttle in December. PMA-1 will provide a pressurized tunnel between the U.S. pressurized elements and the Russian modules. PMA-2 will provide a Shuttle docking location.

- Critical Spares to be flown on flight 2A.1 are scheduled to be delivered in the second quarter of FY 1999 for integration into the Spacehab module. Additionally, the Strela Cargo Crane and the ORU Transfer Device (OTD) are also being delivered for integration into the Integrated Cargo Carrier. Flight 2A.1 is planned to launch in the third quarter of FY 1999.

- Work done in preparation for flight 1R, scheduled to be launched in the fourth quarter of FY 1999, will include the completion of flight article testing, final software deliveries and final crew training. Flight 1R launches the SM that provides all the systems necessary for independent orbital operations and service as a habitat and laboratory.

- Flight 2A.2, planned to be launched in the 4th quarter of FY 1999, was added to the assembly sequence early in the fiscal year. This flight is currently in the planning stages.

- Flight 3A activities in FY 1999 include the completion of MEIT testing and Z1 truss outfitting in preparation for launch in the first quarter of FY 2000.

- Flight 4A activities in FY 1999 include the delivery and integration of major sub-systems including the Early External Active Thermal Control System (EEATCS) and Photovoltaic (PV) Arrays onto the P6. MEIT and P6 final assembly and test will be completed in the fourth quarter of FY 1999. Flight 4A launches in the first quarter of FY 2000.

- Flight 2R, in the first quarter of FY 2000, launches a Soyuz crew transfer vehicle, providing the Space Station with three-person human permanent presence capability.

- During FY 1999, flight 5A will go through extensive testing. MEIT being performed in the last three-quarters of FY 1999, and additional qualification testing at KSC will be completed in this year as well. FY 1999 also includes the completion and delivery of two major pieces of station software - GN&C software (Guidance, Navigation and Control) and Command and Control software.

- The MPLM, which arrived at KSC in FY 1998, will be mated to the Lab and undergo MEIT Testing in FY 1999. The HRF flight rack and its various sub-racks will go through fabrication, assembly, and testing in FY 1999.

- Flight 6A elements are also rigorously tested during FY 1999. The SSRMS, which arrives at KSC during FY 1999, and is mated with the Lab for MEIT testing in the third quarter of FY 1999. Hardware integration onto the SLP (Spacelab Logistics Pallet) begins in FY 1999 in preparation for launch in the third quarter of FY 2000.

- During FY 1999, the airlock, which will be flown on flight 7A, will complete its assembly and checkout and go through element level qualification testing. It will then be reconfigured and shipped to KSC. Once it arrives at KSC, it will undergo pre-integration and leak testing in preparation for launch late in FY 2000.

- The MPLM FM1 is re-used for flight 7A.1. This flight is currently under re-planning preparation for launch in the fourth quarter of FY 2000.

- FY 1999 activities for flight UF-1 include the completion of the MELFI and the Microgravity Sciences Glovebox.

- Many of the ORUs to be integrated on the S0 truss for flight 8A will complete qualification testing and the flight hardware will be delivered during FY 1999. The Mobile Transporter (MT), which is integrated on the S0 truss, will also go through rigorous testing prior to its integration onto the S0 truss segment. The S0 element will be delivered to KSC in the third quarter of FY 1999 where it will begin acceptance testing.

- In preparation for flight UF-2, Mobile Base System (MBS) testing will be completed and the unit shipped to KSC for MEIT 2 in the fourth quarter of FY 1999. EXPRESS Racks scheduled for this flight begin assembly in the fourth quarter of FY 1999.

FY 2000 consists of the launch of seven U.S. flights, two of which (5A and 7A) are considered the most complicated flights in the Space Station Program. Activities in preparation for these flights include:

- Flight 5A launches the U. S. laboratory (Discovery) and five-lab system racks for experiments in the second quarter of FY 2000. Shuttle Integration for this flight occurs in the first quarter of FY 2000. Activation of the Lab initiates U.S. user capability and also provides electrically powered attitude control with the activation of the Control Moment Gyroscopes.

- Flight 5A.1 will launch in the second quarter of FY 2000 with the MPLM. It will carry 6 system racks and an HRF rack for installation into the U.S. Lab.

- Flight 6A, in the third quarter of FY 2000, will launch with the MPLM. It will carry two payload racks for installation into the U.S. Lab, as well as stowage racks, and stowage platforms to carry logistics and re-supply items to orbit. Deployment of the UHF Antenna on this flight provides space-to-space communications capability for U.S.-based space walks. The Canadian SSRMS is also delivered on this flight, providing critical capability for assembly and operations on later flights.

- Flight 7A will launch the airlock and high-pressure gas orbital replaceable unit (ORUs), which are attached to the airlock. The airlock will be delivered to KSC in June 1999 and launched in the fourth quarter of FY 2000. The high-pressure gas assembly supports spacewalk operations and augments the Russian Service Module’s gas resupply system.

- Activities for flight 7A.1 include the turnover of the EXPRESS rack to KSC in the second quarter of FY 2000 for sub-rack (experiment) integration. This activity supports a fourth quarter FY 2000 launch.

- The launch of UF-1 is scheduled for the first quarter of FY 2001, and is currently under review.

- FY 2000 activities for flight 8A, which launches in the second quarter of FY 2001, include acceptance testing and the completion of MEIT 2. Launch package integration and launch processing also occur in this year.

- UF2 is scheduled to launch in the second quarter of FY 2001. It will carry the MBS to be used in conjunction with the MT to provide a base for the SSRMS. This flight is currently under review.

BASIS OF FY 2000 FUNDING REQUIREMENT

SPACE STATION OPERATIONS CAPABILITY

	FY 1998	FY1999	FY 2000
		(Thousands of Dollars)	
Operations capability & construction...	115,100	79,500	39,800
Vehicle operations..	178,700	344,000	540,400
Ground operations	206,400	262,400	270,000
[Construction of Facilities included]	[--]	[1,200]	[--]
Total..	500,200	685,900	850,200

PROGRAM GOALS

The first objective of the operations program is to provide for the safe, reliable and sustained operation of the Space Station as well as the ground operations required to plan, train, and fly the vehicle. The second major goal is to perform the operations in a simplified and affordable manner. This includes NASA's overall integration of distributed operations functions to be performed by each of the international partners in support of their elements. Space Station operations will rely on the infrastructure developed for the Space Shuttle, and the experience derived from the Shuttle-Mir program to develop efficient and effective operations. Finally, operations will facilitate the transition of the various elements of the International Space Station (ISS) vehicle program to the operations program.

STRATEGY FOR ACHIEVING GOALS

In order to increase efficiency and lower the cost of operations, vehicle and ground operations planning began early in the ISS development program. Streamlining and efficiencies with existing programs will be maximized.

Operations capability and construction provides for the development of a set of facilities, systems, and capabilities to conduct the operations of the Space Station. The work will be performed at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC). KSC has developed launch site operations capabilities for conducting pre-launch and post-landing ground operations. JSC has developed space systems operation capabilities for conducting training and on-orbit operations control of the Space Station. Construction of the Neutral Buoyancy Laboratory (NBL) in Houston has been completed, and it is providing the capability for simultaneous EVA training of up to nine Space Station crewmembers at a time. The redesigned Space Station emphasizes multi-center and multi-program cooperation and coordination. At JSC a consolidated approach between Space Shuttle and Space Station minimizes duplicated effort and costs for command and control, as well as training. Crew training will be based on a detailed risk analysis to determine the optimum failure response training profile. Therefore, training will be knowledge- and proficiency-based rather than driven by timeline and detailed procedures rehearsal.

Space Station vehicle operations provides systems engineering and integration to sustain the specification performance and reliability of Space Station systems, logistics support for flight hardware and launch site ground support equipment, configuration management, and any associated procurement activity. Sustaining engineering will be performed, and will be consolidated at the Johnson Space Center (JSC) to allow all flight hardware and software to be handled under a single contract. Maintenance and repair costs continue to be minimized by the application of logistics support analysis to the design, resupply/return and spares procurement processes. Flight hardware spares and repair costs will continue to be controlled by establishing a maintenance and repair capability that effectively utilizes Kennedy Space Center (KSC) and original equipment manufacturers or other certified industry repair resources.

Ground operations provides command and control, training, operations support and launch site processing. A unified command and control center for the Space Station includes the Mission Control Center-Houston (MCC-H) and the Mission Control Center-Moscow (MCC-M) at Kaliningrad. As the flight elements from Europe, Japan and Canada become operational, their respective ground operations functions will be integrated by NASA into the unified command and control architecture. The MCC-H will be the prime site for the planning and execution of integrated system operations of the Space Station. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite System (TDRSS) system and the Russian communication assets.

Flight controllers are being trained to operate the Space Station as a single integrated vehicle, with full systems capability in the training environment. Crewmembers are being trained in the NBL and Space Station Training Facility (SSTF) on systems, operations, and other activities expected during a mission. Part-task and full hardware mockups and simulators are being used to provide adequate training for the crew prior to flight. Integrated training, consolidation of payload and systems training facilities, the concept of proficiency-based learning, and onboard training will increase the efficiency of the overall training effort.

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

Cargo integration support provides accurate, timely, and cost effective planning and layout of cargo stowage items, analytical analysis of cargo/transport systems compatibility, and physical integration of cargo items into the transport carriers and on-orbit ISS stowage systems.

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

SCHEDULE & OUTPUTS

Space Station Training Facility (SSTF)

Primary facility for space systems operations training and procedures verification.

- SSTF Initial Ready for Training (RFT) for flight 5A (slip from 4th Qtr FY 1998 to 4th Qtr FY 1999)
- SSTF Final RFT for flight 5A (1st Qtr FY 2000)
- SSTF Final RFT for flight 2A (4th Qtr FY 1998)
- SSTF Initial RFT for flight 6A (1st Qtr FY 2000)
- SSTF Final RFT for flight 6A (2nd Qtr FY 2000)

*Flights beyond 6A TBD for SSTF

Integrated Planning System (IPS)

Provides planning and analysis tools for pre-increment and real-time operations systems supporting trajectory/flight design, timelines, resource utilization, onboard systems, performance analyses systems operation data file procedures and control, maintenance operations, inventory and logistics planning, robotics analysis, and procedures development.

- Complete ISS MOD Avionics Reconfiguration System (IMARS) development (2nd Qtr FY 1998)
- Complete IPS development (3rd Qtr FY 1999)

Mission Control Center

Facility providing integrated command and control capabilities and support to real-time increment operations.

- Completed Software Verification Facility (SVF) integration test for flights 2A-4A (slip from 2nd Qtr FY 1997 to 2nd Qtr FY 1998)
- Mission Control Center - Houston Configuration Complete for 2A. (slip from 3rd Qtr FY 1997 to 1st Qtr FY 1999)
- Mission Control Center ready to support use of ICM (slip from 3rd Qtr FY 1998 to 2nd Qtr FY 1999)
- Delivery to support flight 5A ISS Command and Control Capability (slip from 4th Qtr FY 1998 to 1st Qtr FY 1999)
- Complete backup control center (control center development complete) (3rd Qtr FY 1999)
- MCC RFT for UF-1 (3rd Qtr FY 2000)

Complete MCC-H/Space Station Training Facility (SSTF) integrated ops training capability Plan: October 1997 Actual: October 1997	Supports the training schedule to train ground crews for real-time operations of the Space Station vehicles.
Baseline SSP 50234, Sustaining Engineering Implementation Plan Plan: January 1998 Actual: April 1998	Required to ensure NASA and its contractors are providing proper skills, tools, processes, and facilities for supporting delivered flight hardware and software.
Baseline SPIP Vol. 10, Sustaining Engineering Plan: January 1998 Actual: June 1998	Standard Program Implementation Plan Volume 10 provides guidance on requirements to ensure provision of proper skills, tools, processes, and facilities for supporting delivered flight hardware and software.
Definitize Sustaining Engineering Contract Mod Plan: March 1998 Actual: December 1998	Required to ensure prime contractor support for delivered ISS flight hardware and software is in place.
Demonstrate MCC-H to MCC-M Command Support Capability Plan: March 1998 Actual: November 1998	Development of the Mission Control Center - Houston (MCC-H) to Mission Control Center - Moscow (MCC-M) command capability. This requirement was met upon completion of end-to-end testing.
Publish MIM 98-1 Plan: April 1998 Revised: December 1998	Annual update of the multi-increment manifest (MIM) covering Program multi-lateral vehicle traffic and crew rotation plan through the assembly period. This update incorporates the Rev. D Modified assembly sequence.
Begin MCC-H ISS flight-following mode with flight 1A/R and 2A Plan: June 1998 Actual: November 1998	The Mission Control Center - Houston (MCC-H) is in a flight-following mode of operations until flight 5A, when NASA takes over primary real-time command and control of the ISS.

Baseline Increment Definition & Requirements Document (IDRD) PP#3 (Preliminary) Plan: April 1998 Actual: April 1998	The IDRD includes requirements and resource allocations for Planning Period 3 that covers the 2000 time frame.
Baseline Increment Definition And Requirements Document (IDRD) for Increment 4 Plan: May 1999 Actual:	Baselining the ISS increment in the Increment Definition and Requirements Document officially initiates increment specific Product and training Development. This typically occurs at 18 months in advance of increment operations. The IDRD is baselined after Multilateral Increment Training Plan is baselined and a detailed ISS crew training plan is developed
SSTF Dual String Capability Plan: June 1999 Actual:	The Space Station Training Facility is a training replica of the ISS on the ground. Dual String Capability will allow two training sessions to be run simultaneously, one of which can be integrated with the Mission Control Center for flight controller training
Baseline Increment Definition And Requirements Document (IDRD) for Increment 5 Plan: August 1999 Actual:	Baselining the ISS increment in the Increment Definition and Requirements Document Officially initiates increment specific Product and training Development. This typically occurs at 18 months in advance of Increment operations. The IDRD is baselined after Multilateral Increment Training Plan is baselined and a detailed ISS crew training plan is developed
Integrated Planning System Final Development Release Plan: September 1999 Actual:	The Integrated Planning System provides the planning and training analysis tools required to support long range mission and vehicle change assessments, mission design, mission and increment planning, pre-mission and contingency analysis, and direct mission support.
Conduct Increment Operations Review for Increment 1 Plan: Sept 1999 Actual:	Formal program review of integrated operations planning product development
Baseline Increment Definition And Requirements Document (IDRD) for Increment 6 Plan: November 1999 Actual:	Baselining the ISS increment in the Increment Definition and Requirements Document Officially initiates increment specific Product and training Development. This typically occurs at 18 months in advance of Increment operations. The IDRD is baselined after Multilateral Increment Training Plan is baselined and a detailed ISS crew training plan is developed

Conduct Increment Operations Review for Increment 2 Plan: Dec 1999 Actual:	Formal program review of integrated operations planning product development
Conduct Increment Operations Review for Increment 3 Plan: March 2000 Actual:	Formal program review of integrated operations planning product development

ACCOMPLISHMENTS AND PLANS

FY 1998

Space Station Control Center (SSCC) activities included completion of the Moscow support room in preparation for the launch of the FGB in early FY 1999. The Houston support room installation was also completed. Interface testing between the Mission Control Center - Houston (MCC-H) and the Mission Control Center-Moscow (MCC-M) began in late FY 1998, and flight 2A end-to-end testing with KSC was completed successfully in early FY 1999.

Space Station Training Facility (SSTF) integration and testing was completed in the fourth quarter of FY 1998 in preparation for flight 2A. The training facility is scheduled to be ready for training for 2A late in the last quarter of FY 1998. Generic training for 2A has been completed. Flight-specific training for 2A also was completed in FY 1998 in preparation for an early FY 1999 launch. Launch processing activities have occurred at the Space Station Processing Facility (SSPF) to support the Integrated Electronic Assembly (IEA) final assembly at the launch site. Delivery and launch site processing of the ISS Z1 truss, long spacer, IEA and MPLM were supported. The Test Checkout and Monitoring System (TCMS) version 2.1, which provides full application software development and end-to-end test capability for flight 6A, was delivered. Version 2.2, which provides Payload Operation Integration Center interfaces and simulation capability to support flight UF-1, was also delivered. The Operations and Checkout Building altitude chamber reactivation was started with an initial design completed and refurbishment activities underway and on schedule. The chamber will be used to vacuum test future ISS elements at the launch site. Initial implementation planning, test objective development, test configuration layout and procedure development began in support of the Multi-Element Integration Test (MEIT). The MEIT will verify the electrical interfaces of Space Station elements. Successful implementation of this test is critical to ensure on orbit performance of the assembled Space Station. Initial set up for this test began late in the fourth quarter of FY 1998.

Operations planning and cargo integration activities include the development and implementation of an Integrated Stowage Plan for pressurized cargo. The process for integrated on-orbit stowage analysis planning was implemented and initiated with Node (flight 2A) stowage rack accommodations planning as well as planning for future missions. Two Zero-G stowage racks were procured, installed into Node 1, and launched on flight 2A in December 1998.

In the logistics and maintenance area, Provisioning Item Orders (PIO's) were issued to begin the initial implementation for the spares hardware build. The Assembly Critical Failures Investigative Team was formed to develop a plan for maintaining critical systems during early assembly. The team identified spares and workaround hardware requirements needed to prevent stoppage in the assembly sequence. The major areas identified were the need for an external spares warehouse, the development of an Early Ammonia Servicer (EAS), and the use of various jumpers as workaround hardware. Assembly critical spares were manifested for flights through 7A.

Sustaining engineering work accomplished in 1998 included the definition, development and implementation of program processes for sustaining engineering. Those processes include those for Government Furnished Equipment (GFE), and Boeing prime and international partners/participants interactions (day-to-day programmatic as well as real-time operations for engineering support). Definition of requirements for and completion of the real-time facilities (mission evaluation room (MER) and engineering support rooms (ESR's) took place. Sustaining engineering support plans for MSFC, JSC and GRC were developed. Design knowledge capture was implemented at all four Boeing sites and a critical skill retention process was initiated at Boeing. Assembly Power Converter Unit (APCU) real-time operations on STS-91 were supported. A generic template schedule and a master-phasing schedule for sustaining engineering products were developed, and a 2A flight-specific schedule for sustaining engineering was baselined. An executable code patch for the Node Control System (NCS) flight software was demonstrated, and a software maintenance consolidation plan for implementation in downstream years was completed. Numerous simulations with the flight control team were also supported.

FY 1999

The Mission Control Center was ready to support flight 2A in the first quarter of FY 1999. In late FY 1999 the Mission Control Center development will be complete. Critical FY 1999 activities in the SSTF include the delivery of training software for flights 2A.1, 2A.2, 3A, 4A, 5A, and 5A.1. Launch site processing work will continue to support launch site testing and launch of ISS flights 2A through 2A.2 and conduct MEIT. Planning and processing support for ISS 7A to UF-1 will be provided and launch site ground support equipment in support of resupply/return flight processing will be delivered. For operations planning and cargo integration, MPLM (flight 5A.1) and airlock (flight 7A) stowage accommodations will be processed and on-orbit stowage planning for flights 2A through 5A will be completed. Nine Zero-G stowage racks will be procured and installed into the Lab (flight 5A).

FY 1999 activities in logistics and maintenance include the identification and issuance of additional PIOs for spares hardware and repair parts. The Super Guppy aircraft will transport the US Lab, S0 structural test article and flight element, airlock, and US Lab structural test article elements to various locations. Manifesting of assembly critical spares for flights beyond 7A will occur this year.

Sustaining engineering planning for 1999 includes providing engineering and technical support required to maintain the hardware post-DD250 for flights 2A - 7A. Real-time engineering support will be provided to the following missions/stages and supporting Progress launches: 1A/R, 2A, 1R, 2A.1, and 2A.2. A remote real-time data access capability for in-home and office use will be implemented. Sustaining engineering products for flights 2A -10A will be produced. Agreements with MSFC, JSC and GRC on sustaining engineering support and required products and schedule as well as the basic sustaining engineering schedule and baseline schedules for flights 3A - UF-3 will continue to be refined. Bilateral agreements on sustaining engineering with Agencia Spatiale Italiano (ASI), RSA, and CSA will be baselined.

FY 2000

Space Station Control Center training software loads will be delivered for flights 6A, 7A, 7A.1, 8A, UF-1, and UF-2. Standalone Payload Training Capability (PTC) will be ready for flight UF-1 and the integrated PTC will be ready for flight UF-2. Launch site processing activities continue in support of launch site testing and launch of ISS flights 3A through 7A.1. MEIT 2 will also be conducted in FY 2000. Planning and processing support will be provided for ISS flights 9A.1 through 13A, and launch site ground support equipment will be delivered in support of re-supply/return flight processing. Operations planning and cargo integration work will include the processing of stowage accommodations and on-orbit stowage. In FY 2000 the program will continue to identify and issue additional PIOs for spares hardware and repair parts. Transportation activities will continue utilizing the Super Guppy for oversize element transportation, and the project will continue to manifest assembly critical spares.

Sustaining engineering activities for FY 2000 includes providing additional engineering and technical support required to maintain the hardware post-DD250 for flights 8A - 11A. Real-time engineering support will be provided to the following missions/stages and supporting Progress launches: flights 3A, 4A, 5A, 5A.1, 6A, 7A, 4R, and 7A.1. Sustaining engineering products for flights 6A through UF5 will be produced. Agreements with MSFC, JSC and GRC on required products and schedule, as well as baseline schedules for flights UF4 through 16A, will continue to be defined. Bilateral agreements on sustaining engineering with ESA and NASDA will be developed.

BASIS OF FY 2000 FUNDING REQUIREMENT

SPACE STATION RESEARCH

	FY 1998	FY 1999	FY 2000
	(Thousands of Dollars)		
Research Projects	113,100	194,500	256,200
Utilization Support	80,500	140,000	138,200
Mir Support (including Mir Research)	32,700	2,000	--
Total	226,300	336,500	394,400

PROGRAM GOALS

NASA will utilize the ISS as an interactive laboratory in space to advance scientific, exploration, engineering and commercial activities. As a microgravity laboratory, the ISS will be used to advance fundamental scientific knowledge, foster new scientific discoveries for the benefit of the U. S., and accelerate the rate at which it develops beneficial applications derived from long-term, space-based research. The ISS will be the world's premier facility for studying the role of gravity on biological, physical and chemical systems. The program will deliver the capability to perform unique, long-duration, space-based research in cell and developmental biology, plant biology, human physiology, biotechnology, fluid physics, combustion science, materials science and fundamental physics. ISS also provides a unique platform for making observations of the Earth's surface and atmosphere, the sun, and other astronomical objects, as well as the space environment and its effects on new spacecraft technologies.

As NASA moves into the Space Station era, there will be a major transition from the current short-term on-orbit experimentation program to the long-term research efforts made possible by the capabilities of the ISS. The core of the Space Station research program will be eight major research facilities: the Gravitational Biology Facility, the Centrifuge Facility, the Human Research Facility, the Materials Science Research Facility (formerly known as the Space Station Furnace Facility), the Biotechnology Facility (which includes Protein Crystal Growth activities), the Fluids and Combustion Facility, the Window Observational Research Facility, and the Low Temperature Microgravity Physics Facility. In addition to the eight major facilities, NASA will develop common-use Laboratory Support Equipment and the Expedite the Processing of Experiments to Space Station (EXPRESS) racks and pallets for the Station.

STRATEGY FOR ACHIEVING GOALS

In 1996 NASA consolidated the management of Space Station research and technology, science utilization, and payload development with the Space Station development and operations program in order to enhance the integrated management of the total content of the ISS budget. The Space Station program manager is now responsible for the cost, schedule and technical performance of the total program. The Office of Life and Microgravity Sciences and Applications (OLMSA), Office of Earth Science, and Office of Space Science remain responsible for establishing the research requirements consistent with the overall Space Station objectives, and funding the principle investigators. The budget reflects this consolidation by funding research capability development within the Space Station account. The research and technology elements of the program, and the Station-related Space Product Development activities are included in the Space Station research budget. A plan for transition of utilization responsibilities back to the research offices once payload facilities are operational will be prepared later this year.

The rephased Assembly Sequence, including the utilization flights, has impacted the planned research program. While still emphasizing early research capabilities, major payload facilities have been delayed on average about eight months. The delivery schedule for research facilities will continue to closely track the buildup of ISS accommodations, in order to ensure the research program ramps up as soon as capability becomes available. The research program will continue to be aligned with the availability of on-orbit resources, including crew time, power and upmass capabilities.

Two research transition flights were added to the Shuttle manifest in FY 1999 and early FY 2001 in order to mitigate research opportunity gaps resulting from the delays in the ISS assembly and utilization schedules. For the FY 2001 mission, the ISS research program will fund an estimated $11.1 million in FY 1999 for payload engineering and integration activities, some experiment unique hardware, and a portion of the carrier cost requirement. The remaining carrier costs and grants and contract costs for the principle investigators will be funded by OLMSA. The FY 2000 requirements are being reviewed in order to fund an appropriate share of the remaining mission costs.

During the early assembly period, the EXPRESS rack program will continue to provide valuable flight opportunities for middeck locker scale experimentation and product development in the areas of biotechnology, biomedical sciences, fluid dynamics and combustion research. Despite delays to the utilization flight plan, we have effectively doubled U.S. research crew time and stowage through our recent negotiations with Russia. The new crew time-stowage balance will position the U.S. for greater experiment productivity from the beginning of the research program. As a direct result, the research program will be significantly enriched because it will allow a greater number of experiments to proceed for longer periods and at increased frequency, thus obtaining many more processed samples and empirical data. Additionally, the ISS program will take advantage of the new logistics flights capabilities of the rephased assembly sequence and will maintain early outfitting by adding the Human Research Facility and two EXPRESS racks on assembly flights 5A.1 and 6A.

Significant progress continues to be made in the establishment of international participation in the provision of U.S. research facilities. The Centrifuge, Centrifuge Accommodation Module, and Life Sciences Glovebox were included in a September 1997 Agreement in Principle with the National Space Development Agency of Japan (NASDA) as partial offset for the Shuttle launch of the JEM. The cryogenic freezer racks and the Minus-Eighty Degree Laboratory Freezer (MELFI) for ISS will be provided by the European Space Agency (ESA) under a March 1997 Memorandum of Understanding. The Brazilian Space Agency (AEB), as a participant in the NASA program, will provide the Technology Experiment Facility, Window Observational Research Facility Block 2, and the EXPRESS Pallet, under an Implementing Arrangement between the U.S. and Brazilian governments.

The Research program is aligned in the following components: Research Projects (including Advanced Human Support Technology, Biomedical Research and Countermeasures, Gravitational Biology and Ecology, Microgravity Research, Space Products Development, Earth Observation Systems, and Engineering Technology), Utilization Support, and Mir Support.

Research Projects

The primary objective of Advanced Human Support Technology (AHST) is the definition, development and testing of advanced technology hardware and processes in support of humans-in-space engineering and life support, and extra-vehicular activity. Specific areas of potential research which have been identified include closed loop life support systems (CO2 reduction and O2 generation), biological water recovery, advanced telemetric biosensors, and wearable computers.

The mission of the AHST research and technology development facility is to identify, develop, and perform flight demonstration, testing, and validation of selected advanced technologies consistent with Space and Life Sciences and the NASA Strategic Plan. These flight experiments will demonstrate miniaturization, low power consumption, high reliability, ease of use, and cost effectiveness for technologies which play a role in life support, environmental monitoring and control, biomedical research and countermeasures, crew health care, and extravehicular activities. The AHST rack will provide a means for taking advanced technologies, which may originate within or outside NASA, to levels of maturity beyond what could be accomplished through ground testing alone. This effort will enable rapid accommodation of advanced technologies into operational systems on the ISS. The initial AHST facility payload on the Station is planned as a single modified EXPRESS rack which will support rotation of subrack payload investigations with a typical duration of 90-180 days.

Biomedical research facilities and activities include the following: the Human Research Facility (HRF), the Crew Health Care Subsystem (CHeCS) and the associated payload development. The HRF provides an on-orbit laboratory that will enable life science researchers to study and evaluate the physiological, behavioral, and chemical changes in human beings induced by space flight. Research performed with the HRF will provide data relevant to long adaptation to the space flight environment. Many capabilities developed for the HRF have Earth-based application. HRF hardware will enable the standardized, systematic collection of data from the Space Station's crewmembers, which the medical and research community will require in order to assure crew health. Once verified on-orbit, the HRF will also be used to conduct basic and applied human research and technology experiments.

In addition to the biomedical research that will be conducted using the HRF, NASA’s biomedical activities aboard the ISS will include the suite of hardware necessary to protect crew health. The CHeCS will support medical care requirements for the ISS crew following deployment of the U.S. Laboratory module. CHeCS hardware will provide inflight capabilities for ambulatory and emergency medical care. It will support monitoring of medically necessary environmental parameters, along with capabilities for counteracting the adverse physiological effects of long-duration space flight. Hardware commonality between CHeCS and the HRF is being evaluated, with the synergy between the two programs resulting in maximum research efficiency and cost savings.

The Gravitational Biology and Ecology facilities and activities include the Gravitational Biology Facility (GBF), the Centrifuge Facility, and associated payload development activities, comprise a complete on-orbit laboratory for biological research. The GBF will design, develop, and conduct the on-orbit verification of Space Station research equipment to support the growth and development of a variety of biological specimens, including animal and plant cells and tissues, embryos, fresh and salt water aquatic organisms, insects, higher plants, and rodents. The GBF will support specimen sampling and storage as well as limited analysis activities. The GBF modular design will accommodate the incremental development of experiment capabilities in a manner consistent with evolving ground and flight science needs of the research community.

The Centrifuge Facility includes two habitat holding systems, a centrifuge rotor, life sciences glovebox, and two service system racks. Under the NASA-NASDA Agreement in Principle, NASDA will provide the centrifuge rotor, life sciences glovebox and the Centrifuge Accommodation Module. A formal implementing arrangement to cover Japans contribution is expected to be concluded in early 1999.

Microgravity Research activities include development of the Fluids and Combustion Facility, Material Science Research Facility, Biotechnology Facility, Low-Temperature Microgravity Physics Facility, and payload development.

The Fluids and Combustion Facility (FCF) supports research on interfacial phenomena, colloidal systems, multiphase flow and heat transfer, solid-fluid interface dynamics, and condensed matter physics, and definition of the mechanisms involved in various combustion processes in the absence of strong buoyant flows. The FCF is a three-rack payload. The Fluids Integration Rack is designed to accommodate several multi-purpose experiment modules that are individually configured with facility-provided and experiment-specific hardware to support each fluids experiment. The Combustion Module houses a combustion chamber that is equipped with ports to allow an array of modular diagnostic systems to view the experiment. The facility core rack will provide common support systems for both the combustion and the fluid payload racks; however, the combustion and fluid racks are being designed to operate as standalone hardware during the Station assembly period with more constrained capability.

The development of the Space Station Furnace Facility (SSFF) was reassessed in FY 1997 and resulted in reduced FY 1999 funding requirements. This project has been renamed the Materials Science Research Facility (MSRF) and is being restructured to provide the maximum opportunity for material research early in the Space Station assembly sequence, with the ultimate goal of a mature 3-rack facility by the end of assembly. This project will be used to study underlying principles necessary to predict the relationships of synthesis and processing of materials to their resulting structures and properties. Cooperative efforts are underway with the international science community that will assist in the development of some discipline-specific furnace modules for use by the U.S. science community, thus leveraging the hardware development investments undertaken by NASA.

The Biotechnology Facility (BTF) supports research in the areas of protein crystal growth and cell tissue cultures which include studies on the maintenance and response of mammalian tissue cultures in a microgravity environment. The facility will provide a support structure as well as integration capabilities for individual biotechnology experiment modules. Its modular design will provide the flexibility to accommodate a wide range of experiments in cell culturing and protein crystallization. The facility will accommodate changes in experimental modules and analytical equipment in response to changes in science priorities or technological advances. The BTF will support a large group of academic, industrial and government scientists.

The objective of the Low Temperature Microgravity Physics Facility (LTMPF) is to investigate the fundamental behavior of condensed matter without the complications introduced by gravity. Primary LTMPF research will study the universal properties of matter at phase transitions and the dynamics of quantum fluids. The LTMPF will be a remotely operated payload package attached to the Japanese Exposed Facility of the Station and is expected to improve measurements by a factor of 100 over similar terrestrial tests. This attached payload facility will support two independent research instruments simultaneously (at a temperature between 0 and 4 degrees Kelvin) and provide 6 to 8 months of microgravity operation between reservicing and hardware changeout.

NASA's commercial research programs for ISS will take advantage of the new opportunities for space flight operations provided by the ISS, and a distinctly new operating environment. Among other activities, the commercial research programs for the ISS will concentrate on commercial protein crystal growth and plant growth research. The commercial protein crystal growth activities for ISS are underway at the Center for Macromolecular Crystallography, and plant growth research at the Wisconsin Center for Space Automation and Robotics, the Center for Bioserve Space Technologies, and their industrial affiliates. NASA released the draft Commercial Development Plan for the ISS in the first quarter of FY 1999. The plan will be refined and initial steps will begin towards implementation later in the year.

Stratospheric Gas and Aerosol Experiment (SAGE III) will measure chemical properties of the Earth's atmosphere between troposphere and the mesosphere. A key aspect of this research will investigate effects of aerosols on ozone depletion in the atmosphere. SAGE III is a payload attached to the outside of the Station and will be mounted on an ESA-provided precision-pointing platform.

The Window Observational Research Facility (WORF) will be located in the U.S. Laboratory Module at the zenith- (Earth) pointing window location. The WORF, which includes a high-quality window and a special rack structure to support optical equipment attachment, will provide a crew workstation for research-quality Earth observations of rare and transitory surface and atmospheric phenomena. The first version, the Block 1 WORF, is being developed as a research testbed for early utilization during the Station assembly sequence. A more mature Block 2 version is planned to be provided by the Brazilian Space Agency as a subsequent upgrade.

The Engineering Research Technology (ERT) program will maximize the use of the ISS as a unique on-orbit laboratory, thereby fostering the partnerships with other U.S. Government, industrial and academic communities. The ERT program will identify and define innovative technology concepts, develop these concepts into flight experiments, and perform the necessary laboratory-scale investigations on-board the ISS to validate the physical characteristics advanced by these concepts. The program promotes the fast track implementation of these experiments. At the same time, the ERT program will obtain proposals for the facilities which can provide the necessary support for one or more experiments to operate without duplication of functions.

The scheduled launch of the various science capabilities mentioned above has been affected by recent implementation of a new assembly sequence and further budget reductions. The new schedule for deployment of these facilities is in work.

Utilization Support

Utilization Support provides the necessary capabilities to integrate and operate payloads of commercial, academic and government researchers on the ISS. These capabilities provide the facilities, systems and personnel to support the ISS user community in efficient and responsive user/payload operations. Support is provided for flight and ground capabilities to ensure efficient and complete end-to-end payload operations. Telescience operations are supported to maintain the highest flexibility for both the user community and NASA at the lowest cost. NASA and International Partner payload operations are integrated to ensure compatible use of ISS resources and to resolve payload requirement conflicts.

Utilization Support provides pre-flight payload engineering integration, verification and checkout support, payload operations integration, payload training, mission planning, real-time operations support, data processing and distribution and launch site support. Services begin with initial definition of the payload for flight and continue throughout onboard ISS operation and return of experiment's data and equipment to the user. Services include documentation of interfaces and verification requirements, training of ground and flight teams, and development and execution of mission plans to meet the needs of the user community. Mission execution activities have been streamlined to allow greater payload operational flexibility.

On the ground, the Payload Operations Integration Center (POIC)/United States Operations Center (USOC), Payload Data Services System (PDSS), and the Payload Planning System (PSS) provide the user community with the tools and resources to access ISS flight payload services and conduct operations from their home laboratories. For those users who do not have access to command and telemetry processing capability at their home location, the USOC provides accommodations for them to conduct their ground-based operations support. Development cost of these systems has been reduced by utilizing generic architecture which supports multiple programs including Space Shuttle, Spacelab, and the Chandra X-Ray Observatory (CXO, formerly known as AXAF).

Utilization Support also assists payload developers through the provision of payload checkout and verification tools needed for development and verification of their payloads. Among the systems provided are the Payload Rack Checkout Unit (PRCU), and the Suitcase Test Environment for Payloads (STEP). A Payload Data Library (PDL) will provide a single electronic interface for payload developers to provide the requirements and data necessary for the ISS to integrate and operate their experiments.

NASA's Utilization Support will also provide the necessary integration across all International Partner payload planning and operations to ensure efficient, compatible use of Space Station payload resources.

In addition to the major facility-class payloads, NASA plans to fly smaller, less complex payloads on the ISS which will typically have more focused research objectives and shorter development time cycles and will be easily adapted to a variety of users. An EXPRESS Rack concept has been adopted to drastically shorten user pre-flight payload preparation activities. The EXPRESS rack will enable a simple, streamlined analytical and physical integration process for small payloads by providing standard hardware and software interfaces. The project flight and ground systems were successfully demonstrated on a precursor flight of an EXPRESS rack in FY 1997 on the MSL-1 Spacelab mission. The EXPRESS pallet project provides small attached payloads with a similar streamlined process and hardware and software interfaces. The Brazilian Space Agency is responsible for developing the EXPRESS pallets for NASA.

Laboratory Support Equipment (LSE) is also under development for the Space Station in order to support Life and Microgravity Sciences and other experiments. This equipment includes a digital thermometer, video camera, passive dosimeter, specimen labeling tools, microscopes, small mass measurement device, pH meter, and an incubator. A cryogenic transport freezer and low-temperature onboard freezers are also being developed to support Station research activities.

Mir Support (including Mir Research)

The Mir program provided for early research opportunities during Phase 1 by conducting long-duration science aboard the Russian Mir space station, as well as shorter duration science investigations on the Space Shuttle rendezvous missions to Mir. Nine Space Shuttle missions to Mir have been completed. The primary objectives of these flights were to rendezvous and dock with the Mir; perform on-orbit, joint U.S./Russian science and research; perform on-orbit joint operations, serve as a platform for future ISS operations; resupply Mir logistics; and rotate the American astronauts on-board Mir. The program was completed with the final flight in May 1998.

<u>SCHEDULE & OUTPUTS</u>

Research Projects

Centrifuge Rotor and Life Sciences Glovebox - Systems Requirements Review (SRR) Plan: 3rd Qtr FY 1998 Actual: 4th Qtr FY 1998	Agreement in Principle signed September 10, 1997. NASDA issued development contracts in early 1998. A System Requirements Review (SRR) and draft Joint Implementation Plan were completed in FY 1998. Experiment Requirements Reviews were completed recently on the Life Sciences Glovebox and Centrifuge Rotor. Preliminary Design Review (PDR) will be held in mid-1999.
FCF Combustion System Preliminary Design Review (PDR) Plan: Under review Revised: 3rd Qtr FY 2000	The FCF program was restructured and a Hardware Concept Review was conducted in FY 1998. A PDR is planned for FY 2000. This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
MSRF Rack 1 Critical Design Review (CDR) Plan: Under review Revised: 4th Qtr FY 1999	This SSFF project was renamed Materials Science Research Facility and restructured and re-baselined in FY 1998. A requirements assessment review was accomplished during the 3rd Qtr FY 1998. The CDR for the first rack will be held late in the 4th Qtr of FY 1999.
CHeCS Complete manufacture and assembly of qualification hardware Plan: 3rd Qtr FY 1997 Revised: 2nd Qtr FY 1999	CHeCS provides crew health care system hardware included in the health maintenance system, and the countermeasure system required to ensure crew health and safety. While the CHeCS rack is not qualified at a system level, the date listed represents the qualification of the last item integrated into the rack.

HRF System CDR, Rack 1 Plan: 1st Qtr FY 1997 Revised: 1st Qtr FY 1999	This review verifies the suitability of the design in meeting the specified requirements and establishes its “build-to” project baseline. 90% of flight drawings should be complete at this stage.
GBF CDR Rack 1 Plan: 3rd Qtr FY 1997 Actual: 3rd Qtr FY 1998	A CDR level review was held for the Habitat Holding Racks. This review verified the suitability of the design in meeting the specified requirements and established its "build-to" project baseline.
Biotechnology Facility PDR Plan: 3rd Qtr FY 2000	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
MSRF Rack 2 Critical Design Review (CDR) Plan: 4th Qtr FY 2000	This review verifies the suitability of the design in meeting the specified requirements and establishes its “build-to” project baseline. 90% of flight drawings should be complete at this stage.
Low Temperature Physics Facility CDR Plan: 4th Qtr FY 2000	This review verifies the suitability of the design in meeting the specified requirements and establishes its “build-to” project baseline. 90% of flight drawings should be complete at this stage.

Utilization Support

EXPRESS Rack Final Testing and Reviews Plan: 3rd Qtr FY 1999	Structural buildup, final documentation, safety reviews and testing are in work. Subrack integration and final acceptance are scheduled in 3rd Qtr FY 1999 for launch on flight 6A.
Complete POIC/USOC and facilities outfitting Plan: 1st Qtr FY 1998 Revised: 4th Qtr FY 1999	Includes workstation upgrades in Payload Operations Integration Center (POIC) and U.S. Operations Center (USOC) at MSFC. Complete communications outfitting 3rd Qtr FY1998, remainder of facilities outfitting 4th Qtr FY 1999 to support UF-1 launch preparations.
EXPRESS Pallet PDR Plan: 2nd Qtr FY 1998 Revised: 3rd Qtr FY 1999	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
Complete PP2 Baseline IDRD Plan: 1st Qtr FY 1998 Actual : 4th Qtr FY 1998	The Interface Definition and Requirements Document (IDRD) describes the on-orbit resources (volume, power, data, etc.) allocated to all payloads. The IDRD for Planning Period 2 (including flight 5A) has been given priority and was baselined in FY 1998.

WORF Block 1 PDR Actual: 4th Qtr FY 1998	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
WORF Block 1 CDR Plan: 4th Qtr FY 1999	This review verifies the suitability of the design in meeting the specified requirements and its "build-to" project baseline. 90% of flight drawings should be complete at this stage.
Payload Crew Training Plan: 2nd Qtr FY1999 Revised: 1st Qtr FY 1999	Training will begin for the first crew operating payloads on 5A.1.
PDSS Initial Operations Capability Plan: 2nd Qtr FY 1999	The capability to process Ku-band telemetry data for the UF-1 and UF-2 missions will be delivered.
Communications Link Activation Plan: 1st Qtr FY 1999 Revised: 2nd Qtr FY 2000	The communication link from the Huntsville Operations Support Center (HOSC) to the Space Station Control Center (SSCC) will be activated to support payload training and operations.
PPS Build 2 Plan: 3rd Qtr FY1999	The Payload Planning System (PPS) capabilities required to support the UF-1 and UF-2 missions will be delivered.

Mir Support (including Mir Research)

NASA/Mir 5, 6,7 Launches Plan: 2nd Qtr FY 1997 (Mir-5) Actual: January 1997 Plan: 3rd Qtr FY 1997 (Mir-6) Actual: May 1997 Plan: 4th Qtr FY 1997 (Mir-7) Actual: September 1997	Spacehab mission management and integration functions for module flights 5, 6, 7, 8 and 9 were performed by Spacehab, Incorporated. Life sciences research on Biorack investigated cellular functions and developmental processes in plant and animal tissues. Microgravity objectives focused on reducing scientific risk and enhancing long duration experiment performance and science utilization in preparation for ISS. A multi-disciplined joint U.S./RSA research program was conducted on a continuous basis on board Mir during this period, and NASA had a U.S. astronaut on board Mir throughout the period.
NASA/Mir-8 Launch Plan: 2nd Qtr FY 1998 Actual: 2nd Qtr FY 1998	Same as above.
NASA/Mir-9 Launch Plan: 3rd Qtr FY 1998 Actual: 3rd Qtr FY 1998	Same as above. Completion of this mission marked the end of Phase 1 of the ISS program.

ACCOMPLISHMENTS AND PLANS

Research Projects - FY 1998

Development of International Space Station facility-class payloads made significant progress during FY 1998.

Structural buildup of the first two EXPRESS Racks, final documentation, safety reviews and testing are in work. The first two racks have begun subrack integration and are scheduled to be accepted in the 3rd Qtr FY 1999 for launch on flight 6A. Ten EXPRESS Suitcase Simulators have been completed.

A Systems Requirements Review (SRR) and draft Joint Implementation Plan for the Centrifuge Accommodations Module, Centrifuge Rotor and Life Sciences Glovebox were accomplished. Buildup of the qualification hardware and the Critical Design Review (CDR) occurred for the Gravitational Biology Facility Habitat Holding Rack. The Cell Culture Unit accomplished a Preliminary Design Review (PDR). The Life Sciences Glovebox completed an Experiment Requirements Review (ERR).

The PDR for Rack 1 of the Human Research Facility was held, and the certifications for the Launch Integration Facility and the Ground Development Facility at JSC were completed. The Flight Prototype Rack was received, and testing of the rack began. Fabrication of the Ultrasound and the Gas Analysis System for Metabolic Analysis Physiology (GASMAP) continued with delivery of flight articles planned in early FY 1999.

The Fluids and Combustion Facility completed a restructure and hardware concept review. The Space Station Furnace Facility was renamed the Materials Science Research Facility and rebaselined during FY 1998. Rack #1 completed a PRR. A CDR was accomplished for the Microgravity Science Glovebox. The Phase l Biotechnology Facility completed operations on the Mir Space Station. The Phase II ISS Biotechnology EXPRESS Subrack configuration continued preparation for flight on UF2.

The Stratospheric Gas and Aerosol Experiment (SAGE III) completed a Systems Acceptance Review (SAR) and Phase 1 Safety Review during 1998. Fabrication of science instrument parts was completed. Flight qualification testing of new detector software code was also completed.

The commercial research program continued to concentrate on commercial protein crystal growth, with the intent to increase the number of samples that can be processed in a given volume, monitor and control growth conditions, and develop a new generation of thermal enclosures for crystal growth.

A communications outage recorder was incorporated into the ISS baseline. A medium rate COR will be launched on 5A.1 utilizing commercial off-the-shelf hardware. A high rate COR will replace the medium rate COR by UF3.

Increment training for the first payloads crews on 5A.1 and 6A began in late 1998. Payloads support to the Multi-element Integration Testing program was initiated with the Human Research Facility Flight Prototype Rack.

A Memorandum of Agreement (MOA) was developed during FY 1997 between the JSC Space and Life Sciences Directorate and the ISS Payloads Office which will permit the sharing of hardware and research between the HRF and the Crew Health Care Subsystem (CHeCS). CHeCS will provide for medical care for the ISS crew following deployment of the U.S. Laboratory module, and will provide operational exercise, countermeasures and environmental monitoring aboard the ISS. As a result of this MOA, which was signed in FY 1998, hardware commonality between CHeCS and the HRF was evaluated, and the efficiency and cost savings of the two programs was maximized.

Research Projects - FY 1999

Development of ISS research facilities and experiment-unique hardware will continue toward launch on 5A.1 and 6A. The Microgravity Science Glovebox training hardware will be shipped to JSC to support the launch on UF-1. The Fluids and Combustion Facility Combustion Integrated Rack will complete a PDR and a Phase 1 Safety Review. The Microgravity Science Research Facility Rack #1 will complete a CDR and Rack #2 will complete a PRR. The Biotechnology Facility will accomplish a Requirements Definition Review (RDR). The Low Temperature Microgravity Physics Facility will finalize the design concept in FY 1999.

The Centrifuge Facility and Life Sciences Glovebox will conduct PDRs in FY 1999. The Gravitational Biology Facility Cell Culture Unit will conduct a CDR, the Insect Container Unit will conduct a PDR, and the Plant Research Unit will conduct a PRR.

Rack 1 of the Human Research Facility will complete a CDR and be delivered to KSC to be flown on flight 5A.1. Rack 2 of the Human Research Facility has been accelerated to fly on 12A.1. Flight units of the following hardware will be delivered: ultrasound, GASMAP, computer workstation, foot/ground interface, activity monitor, continuous blood pressure device, range of motion (ROM) suit, common battery, hand grip dynamometer, and the lower-body negative pressure device. The HRF Flight Prototype Rack (FPR) will be included in the MEIT at KSC in mid-FY 1999. Objectives will be to verify the ISS interfaces (electrical, thermal, communications, data, etc.), verify ISS payload test tools, and to verify HRF integration tools (Launch Integration Facility, Flight Prototype Rack, and Suitcase Test Environment for Payloads). In addition, MEIT will identify potential design problems or incompatibilities between the HRF rack and the U.S. Lab to be resolved prior to launch, and will validate tests and test procedures that will be used in the integration, verification, and flight certification of the HRF Flight Rack for 5A.1.

The Stratospheric Gas and Aerosol Experiment (SAGE III) flight instrument is scheduled for delivery to NASA for launch on UF4. It will complete an instrument CDR and Hexapod CDR during 1999. In addition, flight instruments assembly and subsystem testing will be completed in FY 1999. As part of the ESA Early Utilization Agreement, ESA will provide a hexapod pointing platform for SAGE III which will provide the 1-degree of pointing accuracy required by the payload.

The Engineering Research Technology program will conduct PDRs for the Attitude Control and Energy Stowage Experiment (ACESE) and the Optical Communications Demonstration (OCD) projects in FY 1999. ACESE system and software architecture will be finalized in FY 1999. Interim design reviews will be held for three other projects, Flexible Control Structures; Photovoltaic Engineering Testbed; and the Micron Accuracy Deployment Experiment.

Research Projects - FY 2000

In FY 2000, NASDA will complete the Life Science Glovebox and Centrifuge Facility CDRs. The Human Research Facility Rack #1 will be on-orbit and Rack #2 will be readied for launch on 12A.1.

The Microgravity Sciences Glovebox and the Minus Eighty-Degree Laboratory Freezer (MELFI) will be readied for launch on UF-1

The Fluids and Combustion project will accomplish the Shared Accommodation Rack, Fluids Integrated Rack and Integrated Facility PDRs and the Combustion Integrated Rack CDR. Outfitting of the Combustion Integrated Rack will be completed and system and subsystem testing accomplished. The Microgravity Science Research Facility Rack #2 will complete its CDR. The ISS Biotechnology Facility will complete a PDR, the EXPRESS Rack level biotechnology and fluid physics payloads will be on-orbit, and the Low Temperature Microgravity Physics Facility will complete a CDR.

Utilization Support - FY 1998

In FY 1997, a decision was made to defer full payload operations support capability to the UF-3 time frame consistent with Space Station funding priorities for FY 1998. Requirements for initial operations capability (IOC) in the POIC, PDSS, PPS, and Payload Training Center (PTC) have been changed to support flights 5A.1 and 6A for the first use of payloads on the ISS based on the current assembly sequence. Payload training plans and simulator requirements were defined for the 5A.1 and 6A payloads, and the first two STEP units were delivered to payload developers.

The Payload Data Library (PDL) initial data set development was completed in FY 1998. The Payload Rack Checkout Unit (PRCU) development was delayed due to late software delivery from the Space Station vehicle. The first PRCU was delivered in FY 1998. Payload integration for 5A.1 and 6A payloads has begun, including development of preliminary ICDs and Payload Integration Agreements (PIAs) for payloads.

In FY 1998, development of the initial operations capability to support 5A.1 and 6Aby the POIC, PDSS, PDL, PTC and PPS continued. The support communications services for the POIC/PDSS were put in place, enabling connectivity between the POIC and remote payload investigators. PPS Build 1 test and integration were completed and flight product development for payload complement began. The payload unique ICDs and verification plans were completed and the PIAs were baselined.

Fabrication and testing of the first EXPRESS rack to fly on the ISS began in FY 1998. The first EXPRESS racks are planned for launch on flights 6A and 7A.1. A total of 10 “suitcase” EXPRESS rack interface simulators are being fabricated for use by EXPRESS payload developers. All ten simulator units were delivered to payload development sites in FY 1998.

The Window Observational Research Facility (WORF) design was upgraded to incorporate the ISPR rack, and operational responsibility was transferred to MSFC to leverage off the EXPRESS Rack experience and hardware. WORF payload services were upgraded to include power, data and thermal control. A SRR and PDR were completed.

An implementing arrangement was signed in October 1998 to transfer development responsibility for the EXPRESS Pallet to the Brazilian Space Agency. EXPRESS Pallet engineering integration, payload software verification, and on-orbit operations will remain the responsibility of NASA. A Joint Management Plan for pallet development was completed. A PDR for the pallet is scheduled for FY 1999 for a first flight on UF-3.

Utilization Support - FY 1999

In FY 1999, the Huntsville Operations Support Center (HOSC) will be declared operationally ready to support 5A.1 and 6A payload operations. Many of the flight products will be completed and integrated with the systems operations products. The first payload crew will begin training for the missions and the integrated engineering and operational assessments will be performed for the payload complements. Development will continue on the final operations capabilities of the PDSS, PPS, and PTC to support the UF-3 mission.

During FY 1999, the first four EXPRESS Racks will be readied for delivery to KSC and launch on flights 6A and 7A.1. EXPRESS Rack trainer units are to be completed in the first quarter of FY 1999. These units will be used for procedure development and crew training to support the 6A and subsequent flights. Subsystem hardware integration and verification will be completed by mid 1999. In addition, four EXPRESS Transportation Racks will be delivered to NASA used for transporting EXPRESS payloads to and from EXPRESS racks already on-orbit.

A PDR for the EXPRESS Pallet is scheduled for FY 1999.

An Operational Readiness Review (ORR) for the Telescience Support Center (TSC) will be held for JSC. Crew training in the Ground Development Facility (GDF) will begin for activation of the rack on-orbit and human research experiments to be conducted, followed by start of training in the Hi Fidelity Mock-up.

The Window Observational Research Facility (WORF) will accomplish its CDR and deliver the flight rack to KSC for flight on UF2. Installation of the optical quality window glass in the U.S. Laboratory module is scheduled for the third quarter of FY 1999.

Utilization Support - FY 2000

Four EXPRESS Racks will be on-orbit and conducting operations. Delivery, final testing, and subrack integration for the fifth EXPRESS Rack and the Window Observational Research Facility will be completed for launch on UF-2.

Mir Support – FY 1998

During FY 1998, two Shuttle flights to Mir were flown which included one Spacehab double module in January and one single module in May. American astronauts spent eight months aboard Mir conducting research. The Phase 1 Mir program concluded its flight program in mid-year after nine successful Shuttle flights.

Mir Support – FY 1999

The data analysis and publication of results from the Phase 1 Mir research program will be completed in FY 1999.

BASIS OF FY 2000 FUNDING REQUIREMENT

SPACE STATION RUSSIAN PROGRAM ASSURANCE

	FY 1998*	FY 1999**	FY 2000
		(Thousands of Dollars)	
Step one	[50,000]		
Step two	[60,000]	248,300	200,000
Total..	[110,000]	248,300	200,000

* In FY 1998, Russian Program Assurance (RPA) was funded in the US/Russian Cooperation and Program Assurance budget line item within the Human Space Flight appropriation account. It is displayed within the International Space Station account to reflect the FY 2000 restructured budget.

** The December 22, 1998 operating plan includes $53 million for Russian Program Assurance (RPA) for FY 1999. This budget assumes additional reallocations of $195.3 million from Vehicle to RPA in FY 1999.

PROGRAM GOALS

In FY 1997, the budget line item entitled, U.S./Russian Cooperation and Program Assurance, was established. This budget line item had two parts, U.S./Russian Cooperation (Russian Space Agency contract support) and Russian Program Assurance (RPA). The first part has been completed. The second part, Russian Program Assurance (RPA), was re-established within the Space Station budget line. The RPA budget was established to fund contingency activities and backup capabilities in response to concerns about the impact of the Russian Government's fiscal problems on meeting their ISS commitments. These concerns were heightened by the slippage of the Russian service module (SM) from May 1998 to December 1998, and then to the fourth quarter of FY 1999.

NASA’s approach to contingency planning is to incrementally fund only those activities that permit the United States to continue to move forward should the planned contributions of our ISS partners not be delivered as scheduled, rather than to assume the responsibilities of other ISS partners. It is a process based on: 1) identification of risks; 2) development of contingency plans to reduce these risks; 3) establishment of decision milestones and the criteria by which action will be taken; and, 4) implementation of contingencies as necessary. The RPA funding provides contingency activities to address ISS program requirements resulting from delays on the part of Russia in meeting its commitments to the ISS program, allowing the U.S to move forward and build the ISS in spite of Russian shortfalls. These contingency activities are not intended to protect against the loss of Russian contributions. That impact would cause an extended delay to the program, necessitating additional crew return, life support, reboost, and guidance and control capabilities to replace planned Russian contributions, and result in a significantly less robust space station.

BACKGROUND

For several years Russia has experienced significant economic problems. The fiscal shortfalls experienced by the Government of Russia have resulted in the Russian Space Agency (RSA) receiving only a fraction of its approved budget. The shortfalls have resulted in schedule slips of the ISS hardware and operations support that Russia was responsible for funding and providing. To accommodate this shortfall, the U.S. developed a three step contingency plan and initiated specific developments to protect the ISS schedule and capabilities in the event of further Russian delays or shortfalls. In spring 1997, NASA embarked on the initial steps of a contingency plan to provide U.S. capabilities to mitigate the impact of further Russian delays. Step one consisted primarily of the development of an Interim Control Module (ICM), built by the U.S. Naval Research Laboratory for NASA, to provide command, attitude control, and reboost functions in the event the Russian Service Module was not provided. Over the last year we have continued to see further delays on the Russian elements. Therefore, during summer 1998, NASA initiated activities to implement Step two of the contingency plan to provide flexibility for the United States in the event of further Russian delays. Step two consists primarily of building a U.S. propulsion capability, enhancing logistics capabilities, modifying the Shuttle fleet for enhanced Shuttle reboost of ISS, and procurement of Russian goods and services to support Russian schedules for the Service Module and early ISS Progress and Soyuz launches. NASA expects to procure some additional Russian hardware and services in FY 1999 to provide further Russian schedule protection.

STRATEGY USED FOR ACHIEVING STEP ONE GOALS

The U.S./Russian Cooperation and Program Assurance (RPA), as part one Step one, was initiated in May 1997. It provided contingency planning funds to address ISS program requirements resulting from delays on the part of Russia in meeting its commitments to the ISS program. The first step in the contingency plan, which was to protect against a potential further delay in the SM, has been implemented. The ISS program is purchasing an interim control module (ICM) from the U.S. Naval Research Laboratory (NRL) to provide the U.S. with an option for performing attitude control and reboost functions which the Russian service module is to perform. This option could allow continuation of the ISS assembly sequence without the Russian SM. The NRL's ICM is currently being prepared to support a March 2000 launch to back up any shortfall of Progress fuel resupply vehicles. The Program is also maintaining an option to attach it to the back of the Russian-built functional cargo block (FGB), should the Russian Service Module slip considerably beyond its scheduled launch in the fourth quarter of FY 1999.

Step One of NASA's RPA contingency plan had two primary components. First, modifications were done to the Zarya, an element purchased from Russia and owned by the U.S, to enhance the Zarya's propulsion control capabilities and make it refuelable. The Zarya was launched on November 20, 1998. Second, the development of an interim control module (ICM)was initiated. The Zarya modifications and the ICM addition will enable the on-orbit build to continue even without the Russian Service Module, although not as planned due to the loss of the Service Module's habitation resources. This would result in increased risk due to the absence of an ISS-based crew to address real-time problems, which can be expected to arise. It would also result in lost research opportunities, resulting in a significant research gap or the introduction of new Shuttle based research opportunities. Other RPA activities included purchase of docking adapters and SM flight support equipment from RSA, airlock modifications, O^2 compressor for the airlock, and other related ICM tasks. In 1999, RPA funding for Step one will support the completion of assembly, test and checkout of the ICM.

STRATEGY USED FOR ACHIEVING STEP TWO GOALS

During summer 1998, NASA undertook initial efforts in Step two of the contingency plan to provide flexibility for the United States and our international partners in the event of further Russian delays. These efforts included initiation of development of an enhanced Shuttle reboost capability for the ISS. This long-term reboost capability will augment the existing Shuttle reboost capability, and will be obtained by modifying the Shuttle orbiters so that the maximum amount of excess maneuvering propellant can be utilized by the Shuttle to reboost the ISS while docked. Also as part of Step Two, to further reduce U.S. reliance upon Russian contributions, NASA is proceeding with the development of a U.S. propulsion capability which would provide permanent, independent reboost and attitude control. NASA will continue to evaluate options for securing a permanent U.S. propulsion capability into the second quarter of fiscal year 1999, in parallel with performing prestart requirements analysis and long lead procurements for a Boeing proposed propulsion module. A decision is planned in the second quarter of FY 1999 to authorize a new development project to provide a U.S. propulsion capability.

In parallel to the development of independent U.S. capabilities for long-term self-reliance, NASA has maintained a regular dialogue with RSA representatives to fully understand their fiscal situation. The Administration and the Congress responded affirmatively to NASA's September 1998 recommendation to provide the RSA immediate funding to help ensure timely delivery of the critical Russian Service Module and to avoid costly delays in the first launches of ISS hardware. NASA entered into a contract with the Russian Space Agency to secure valuable crew time to conduct U.S.-directed research, and procure critically needed research stowage space. This agreement, funded at $60 million, provided funds that allowed RSA to maintain delivery schedules for the Service Module and other early Russian contributions.

To ensure uninterrupted continuation of ISS assembly, including certainty regarding availability of Russian Progress and Soyuz vehicles--at the same time that development of independent U.S. capabilities is being pursued--NASA's contingency planning envisions the possibility of further negotiation with Russian entities for purchase of appropriate goods and services in the future. Consistent with direction in the FY 1999 VA-HUD-Independent Agencies appropriations bill (P.L. 105-276), NASA is evaluating alternative approaches whereby NASA could contract with Russian entities for goods and services related to the ISS. This report should be completed in the second quarter of FY 1999. Where appropriate, NASA is prepared to competitively bid these requirements. NASA has continued discussions with the RSA regarding the purchase of a Soyuz return vehicle as well as the purchase of Soyuz trainers, increased stowage, and other goods and services. The purchase of a Soyuz is highly desirable because it will enable deployment of six crew to orbit prior to the availability of a U.S. Crew Return Vehicle (CRV). At present NASA can not achieve an increased crew complement on orbit until the U.S. Crew Return Vehicle is completed and operational. NASA is considering a Soyuz purchase in the second quarter of FY 1999.

NASA believes that this approach, working with Russia to assure near-term critical capabilities while developing independent U.S. capabilities over the long-term, provides the best approach to address the impacts from the Russian economic situation. NASA will be prepared to provide some of the logistics requirements that Russia agreed to provide, should RSA experience insufficient funding from their government. This will require Shuttle logistics flights for dry cargo and reboost of the ISS stack, as well as the procurement of logistics carrier support until a permanent U.S. propulsion capability is delivered. The potential use of orbiter vehicle OV-102 to meet some of these logistics requirements requires the installation of a docking module and this is also included in Step 2. The International Space Station Intergovernmental Agreement and the bilateral Memorandum of Understanding between NASA and RSA provide the flexibility to modify Russian participation in the ISS Program through a rebalancing of partner contributions and benefits.

SCHEDULE & OUTPUTS

ICM CDR Plan: December 1997 Actual: December 1997	NRL and ISS program office completed the critical design review (CDR) for the ICM
SM Launch Plan: December 1998 Revised: 4th Qtr FY 1999	The SM will be launched as part of the ISS Revision D Assembly Sequence
FDRD Completed Plan: February 1998 Revised: June 1999	Flight design requirements document (FDRD) baseline established in order to allow Shuttle to begin flight design processes
ICM Cargo Integration Review Plan: April 1998 Revised: October 1999	Review of cargo element with Shuttle Program
ICM Phase III GSR Plan: October 1998 Revised: March 1999	Phase III ground safety review at KSC
ICM Stage Integration Review Plan: November 1998 Revised: January 1999	Stage integration review
ICM Ship to KSC Plan: December 1998 Revised: Fall 1999	Begin launch processing, ground operations at KSC
ICM Launch Readiness Plan: February 1999 Revised: 2nd Qtr FY 2000	Planned launch date if Russian service module is delayed or Progress vehicle shortfall

RCM PDR Plan: July 1999	Reaction Control Module (RCM) is an option being reviewed to provide U.S. propulsion capability. Schedule estimate for RCM Program Design Review if authorization to proceed is provided in January 1999
RCM CDR Plan: February 2000	Estimated schedule for Reaction Control Module Critical Design Review if authorization to proceed is provided in January 1999
RCM-1 delivery Plan: August 2001	Estimated schedule for First Reaction Control Module delivery if authorization to proceed is provided in January 1999
RCS Interconnectivity Modifications, and Orbital Fluid Transfer System Plan: 2nd Qtr FY 2001	Provides orbiter mods to reaction control system (RCS) to enhance Shuttle reboost capability, and mechanisms to enable transfer of propellant between orbiters and ISS propulsion module. Orbiter fleet will be modified during Orbiter Maintenance Down Periods (OMDPs). Estimated schedule for first unit is second quarter of FY 2001.

ACCOMPLISHMENTS AND PLANS

In FY 1998, RPA major activities included continuation of FGB performance modifications, airlock modifications, and docking adapters. Activities accomplished in building the ICM include:

- Completion of design and requirement modifications
- Inspection and refurbishment of the primary structure
- Completion of the build and testing of the 110 lb Thruster Engine
- Receipt of both the active and passive Russian Androgynous Peripheral Assembly System (APAS) adapters

Funding totaling $200 million was originally identified in FY 1997 for RPA. Subsequent decisions and development problems slowed work on the ICM and associated flight and ground equipment and activities. The schedule for completion of the ICM has been extended. As a result, NRL informed NASA in mid-1998 that they would not be able to obligate FY 1997 funds as planned, prior to the end of FY 1998. NASA received approval of its revised FY 1997 operating plan to use $23 million of FY 1997 funds to initiate work on orbiter interconnectivity modifications. This will ensure the timely development of the orbiter design to enable modification of Orbiter Vehicle 102 during its upcoming Orbiter Maintenance Down Period (OMDP). The Shuttle fleet will be modified to augment existing Shuttle reboost capability for the ISS. This effort would be accomplished over the next several years. The first availability for this augmented orbiter reboost capability for ISS assembly is currently anticipated to be in the 2002/2003 time frame. A formal contract proposal from the Boeing Company and United Space Alliance is being evaluated.

FY 1999

- ICM activities include completion of all subsystem development, test and integration, flight software build and test, and preparation for shipment to the KSC launch site.

- Continue to perform prestart requirements analysis and long lead procurements to enable 2002 U.S. propulsion capability deployment. A decision will be made in early part of the second quarter of FY 1999 to authorize its procurement

- Orbiter interconnect design, development and hardware procurement activities for the Orbiter Reaction Control System enhancements.

- Docking module modifications will be performed on OV-102 during its maintenance down period to allow Columbia to rendezvous and dock with ISS for additional ISS logistics and reboost support.

- If authorization to proceed is provided in January 1999, the Preliminary Design review for a U.S. Reaction Control Module will likely occur in the last quarter of FY 1999

FY 2000

- The ICM is planned to be shipped to KSC early in FY 2000 where it will undergo End-to-End testing, launch processing, and shuttle integration if required to support a Russian shortfall.

- Pressurized logistics support carrier provided for the new logistics flights 5A.1 and 7A.1 resulting from Russian flight readiness delay of initial Progress flights to ISS and existing logistics backlog during the U.S. Laboratory deployment timeframe.

- During the OV-103 maintenance down period scheduled for the fourth quarter of the fiscal year, Discovery will become the first Shuttle to be outfitted with the Reaction Control System enhancements.

If authorization to proceed is provided in January 1999, the Critical Design review for a U.S. Reaction Control Module will likely occur in the first quarter of FY 2000.

BASIS OF FY 2000 FUNDING REQUIREMENT

SPACE STATION CREW RETURN VEHICLE

	FY 1998	FY 1999	FY 2000
		(Thousands of Dollars)	
Crew Return Vehicle	--	--	148,000

PROGRAM GOALS

The safety of the crew for the International Space Station is of critical importance. The Russian Soyuz vehicle has provided a contingency capability for life threatening emergencies that may arise during extended stays on orbit on the Mir and will do so for the initial years of the ISS. Continued reliance on the Soyuz limits the crew size for the ISS and poses significant operational and programmatic risks. Each Soyuz can only transport a crew of 3 and has to be changed out after about six months on orbit. A more capable crew return vehicle that overcomes the limitations of the Soyuz is viewed as the most viable long term approach for ensuring crew safety. A goal of the Crew Return Vehicle (CRV) project is to leverage the technologies, processes, test results, and designs developed in the preliminary technology development work carried out in the X-38 project and related contractor studies of a CRV.

The Crew Return Vehicle (CRV) project will provide an independent U.S. crew return capability for the ISS beginning in FY 2004 and will be sustained for the life of the Station. The CRV will accommodate safe return for up to seven crew under the following scenarios:

- Crew member(s) ill or injured while the space shuttle orbiter is not at the station
- Catastrophic failure of the station that makes it unable to support life and the space shuttle orbiter is not at the station or is unable to reach the station in the required time
- Problem with the space shuttle that makes it unavailable to re-supply the station or change-out crew in a required timeframe

STRATEGY FOR ACHIEVING GOALS

NASA has funded the X-38 project to develop more fully the technology and design basis for a CRV. The X-38 design has a strong foundation from the lifting body research and technology developments carried out since the 1960's. NASA will also take advantage of the related efforts which are more focussed on alternatives to the Space Shuttle to carry crew into orbit, as well as return crew from orbit. A final design decision on whether to follow the X-38 path or to incorporate alternative design concepts will be made in FY 2000. The decision will be closely tied to progress on the X-38, alternative design concepts, and the results of the Future Launch Studies. NASA's objective is to have the first vehicle available for deployment to the Space Station in 2004. which is focused on forming the foundation for generic low cost human-rated spacecraft.

If the X-38 path were selected, the transition from X-38 research and development to CRV design and development would occur in early FY 2000 as X-38 work phases out and CRV work phases in. This transition plan for the X-38 path is as follows:

- Phase 0 - An unfunded observation period in which contractors interact with the X-38 project team. This effort began 20 July 1998 and will run through Final RFP release for Phase 1 in March 1999. Five companies are currently participating in this phase. This phase is performed with X-38 Advanced Projects funding.
- Phase 1 - Multiple contractors will perform delta design tasks to convert the X-38 design into an operational CRV design and participate in flight-testing. The X-38 space flight test is currently scheduled to occur in the first half of FY 2000. At the end of Phase 1 (approximately 1 year) the final build-to-specification (or possible build-to-print) configuration of an X-38 based CRV will have been established. All drawings, prints, schematics, and software will be owned by the government at the end of Phase 1. As the transitional phase, Phase 1 is budgeted partially by X-38 Advanced Projects and partially by the CRV funding requested above.
- Phase 2 - Currently planned as a fixed price production of the CRVs by industry. The contractor will be selected by a competition based on the released drawings for the vehicle. This phase is budgeted by the CRV project.

These three phases will include three primary tasks:

- Perform delta design tasks necessary to convert the X-38 design into an operational CRV design, and perform necessary system integration internally and with STS and ISS.
- Perform atmospheric and space flight tests of X-38 prototype vehicles.
- Perform production of the CRV operational vehicles.

A total of four flight units are viewed as needed to meet ISS crew return requirements, assuming the ISS has at least one and perhaps two vehicles present on the Station at any time. The requirement for one or two CRVs on the station is currently as part of system trade studies.

SCHEDULE & OUTPUTS (X-38 PATH)

Start Contractor Observation period Plan: July 1998 Revised: Completed	Beginning of period in which potential contractors observe X-38 Program flight demonstration test and development activity.
CRV Request For Proposal release for Phase 1 Plan: March 1999 Revised: TBD	Release RFP for a funded period in which multiple contractors will perform delta design tasks to convert the X-38 design in an operational CRV design and participate in flight-testing.

Phase 1 Start Plan: October 1999 Revised: TBD	Multiple contractors will perform delta design tasks to convert the X-38 design in an operational CRV design and participate in flight-testing.
Design Freeze for Phase 2 RFP Plan: September 2000 Revised: TBD	Freeze CRV design based on X-38 experience to date and use for basis of CRV development contract.
Award CRV development contract Plan: December 2000 Revised: TBD	Contractor Award of CRV development contract.

ACCOMPLISHMENTS AND PLANS – FY 2000

In FY 2000 the design approach decision will be made for the CRV project. If the decision is to proceed with developing the design of the CRV using the X-38 space test vehicle as the basis of design, the following provides an indication of the design and development work which would be conducted, using both civil servants and contractors to firm up the design.

CRV Vehicle Subsystems

NASA Tasks

Avionics work would include continued development of the CRV inertial guidance system (SIGI – System of Interactive Guidance and Information); avionics instrumentation; radiation-hardened computer system network elements; operating system software; and communication system signal processors. Flight dynamics work would include simulation-based development and verification of the CRV flight controls. Mechanisms work will include delivery of electro-mechanical actuators (EMAs) and laser pyros, and EMA testing. Parafoil work would continue with testing, new parafoil procurements, and integrated structural dynamic modeling. Thermal Protection System component procurement will begin.

Phase 1 Contractor Tasks

Contractor tasks would be focussed on designs of avionics computers, networks and data busses; instrumentation and sensors; electrical power system; communications system; engineering support; laser altimeter; data recorder; avionics testbed; human computer interface; flight software; and interconnect wiring and connectors. Mechanisms work will be performed on the berthing/docking design and fin mechanisms. Manufacturing work would begin on the berthing/docking module; metallic structural parts materials and machining; composite structural parts materials and manufacturing; and tooling. Structures work would begin on structural, hatch, window and couch design.

Systems Engineering and Operations

Safety, Reliability, and Quality Assurance, and Systems Engineering and Integration work would be performed as NASA primary tasks supported by the Phase 1 contractors

Operations tasks include analyses of CRV separation (from Space Station) dynamics, continuing development of landing site and site selection requirements, and development of crew displays and controls requirements. Mission operations tasks include Mission Control Center and facility design requirements, modeling, and development of flight and ground procedures and flight rules. Logistics and maintenance tasks would focus on development of a spares program. Kennedy Space Center tasks include development of launch support and logistics flight operations requirements.