INTERNATIONAL SPACE STATION

FISCAL YEAR 2001 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE STATION**

SUMMARY OF RESOURCES REQUIREMENTS*

	FY 1999 OPLAN 12/23/99	FY 2000 OPLAN REVISED	FY 2001 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Vehicle	1,183,900	890,100	442,600	HSF 1-6
Operations Capability	576,300	763,600	826,500	HSF 1-18
[Construction of Facilities included]	[1,200]	[--]	[--]	
Research	336,500	394,400	455,400	HSF 1-27
Russian Program Assurance	203,000	200,000	300,000	HSF 1-40
Crew Return Vehicle	--	75,000	90,000	HSF 1-45
Total	2,299,700	2,323,100	2.114,500	

Distribution of Program Amount by Installation

	FY 1999 OPLAN 12/23/99	FY 2000 OPLAN REVISED	FY 2001 PRES BUDGET
Johnson Space Center	1,868,900	1,710,100	1,512,100
Kennedy Space Center	114,300	113,300	92,900
Marshall Space Flight Center	221,000	391,200	327,000
Ames Research Center	42,000	47,100	77,900
Langley Research Center	5,100	800	4,100
Glenn Research Center	40,500	40,700	75,000
Goddard Space Flight Center	900	300	
Dryden Flight Research Center		2,500	6,000
Jet Propulsion Laboratory	5,400	12,100	14,500
Headquarters	1,600	5,000	5,000
Total	2,299,700	2,323,100	2,114,500

* Summary adjusted to reflect the effect of restructured budget in FY 2000, and prospective reallocations to the FY 1999 operating plan, and to the FY 2000 operating plan. The December 23, 1999 operating plan for FY 1999, and this estimate, includes $203

million for Russian Program Assurance (RPA). NASA has not submitted to Congress the intended increase of $100 million for RPA for Operating Plan consideration, pending further discussions with Rosaviakosmos, the Russian Aeronautics and Space Agency. This budget also assumes an additional reduction in FY 2000 of $11.5 million from Operations in order to implement the 0.38% rescission enacted, and a reallocation of $21 million from Operations to maintain the Phase 1 development for the Crew Return Vehicle (see special section "FY 2000 Changes").

PROGRAM GOALS

The goal of the International Space Station (ISS) is to establish a long-duration habitable residence and laboratory for science and research and permanently deploy a crew to this facility. The ISS will vastly expand the human experience in living and working in space, encourage and enable commercial development of space, and 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 critical 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 is 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 baseline program content includes ISS vehicle development, operations capability, research, and has been expanded to enable the development of a U.S. crew return capability, and a number of contingency activities provided within Russian Program Assurance. Extensive coordination with the user community is well underway, and payload facilities development and research and technology activities are 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). OLMSA has administrative responsibility for the ISS Research program starting in FY 2000.

The ISS represents an unprecedented level of international cooperation. Space Station Partnership agencies include NASA, the Russian Aviation and Space Agency (Rosaviakosmos), 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.

Russian contributions to the ISS include the Service Module, universal docking module, science power platform, docking compartment, life support module, and research modules. The Service Module will provide early sleeping and living quarters for crew members. Russia will also provide logistics resupply and station reboosting capability with the Progress and other vehicles, as well as crew transfers aboard the Soyuz vehicle. Russian participation in the space station is significant, providing for a more capable research laboratory, able to sustain a larger crew of researchers than would have been possible without them. They contribute the Soyuz crew module. This makes it possible to place crews aboard to conduct research during the assembly sequence, instead of having to wait until the station is completed and a U.S. crew return capability is available. They also provide Progress supply transports, which provide a great deal of the resupply needs, both during assembly and during ten years of operations.

Canada's contribution to the ISS is the Mobile Servicing System (MSS) and its associated ground elements. The MSS will provide a second-generation robotic arm similar to the Canadian arm developed for the Shuttle. The MSS consists of the 58-foot long Space Station Remote Manipulator System (SSRMS) that can handle masses up to 220,000 pounds, a Base System, and a 12-foot robotic arm called the Special Purpose Dexterous Manipulator (SPDM) that attaches to the SSRMS. CSA has developed a Space Operations Support Centre, MSS Simulation Facility and Canadian MSS Training Facility. CSA's Space Station utilization allocation is 2.7%.

The National Space Development Agency of Japan (NASDA) will provide the Japanese Experiment Module (JEM), which consists of a number of different components. Those components include the following elements: a Pressurized Module (PM), a pressurized laboratory that provides 77% of the utilization capability of the U.S. laboratory and can accommodate 10 racks; an Exposed Facility (EF) for up to 10 unpressurized experiments; a 32-foot robotic arm used for servicing system components on EF and changing out attached payloads; and an Experiment Logistic Module (ELM) for both pressurized and unpressurized logistics resupply, and the HII Transfer Vehicle (HTV) for ISS logistics resupply.

European Space Agency (ESA) contributions emphasize their role in early and continued utilization of the ISS and augmenting the ISS infrastructure. The ESA contributions include: the Columbus Orbital Facility (COF) with accommodations for 10 standard racks; the Automated Transfer Vehicle (ATV) for ISS logistics resupply, propellant resupply and reboost missions, to be launched by the Ariane 5 launch vehicle: and cooperation on the X-38, which is the protoflight vehicle for the ISS Crew Return Vehicle (CRV). ESA will also participate on the CRV as well. ESA has also made separate arrangement with the Russian Aviation and Space Agency for two contributions to the Russian elements: the European Robotic Arm (ERA) on the Russian Science and Power Platform and the Data Management System (DMSR) for the Service Module.

Additionally, there are several bilateral agreements between NASA and other nations such as Italy and Brazil, resulting in a total number of fifteen U.S. international partners. 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 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.

Through FY 1999, the ISS cooperative international agencies, excluding Russia, had invested over $5 billion dollars in design and development activities, of a total estimated investment expenditure of approximately $9 billion. Because Russia's transition to a free market economy is still underway, it is not possible to accurately project their financial investment. However, their hardware contribution is approximately a third of the mass of the completed assembly of the ISS and will provide nearly half of the pressurized volume of the ISS.

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 the initial phase, which were successfully accomplished, were to develop and demonstrate joint mission procedures with Russia, gain valuable experience to reduce technical risk during International Space Station construction, and provide early opportunities for extended scientific research.

The next phase of the program began with the launch of the U.S.-owned/Russian-launched Zarya propulsion module in November 1998, which was soon followed by the Shuttle deployment of the U.S. Unity module in December of 1998. Since then, most ISS on-orbit systems have been performing above expectations, with few anomalies. The transition of U.S. and Russian space station operations leadership, from Russia during Shuttle-Mir, to the U.S. lead responsibility for the ISS stack has been carried out exceptionally well. This phase, which concludes with the launch of the airlock on flight 7A, will establish the initial research capability for ISS. The initial crew of three persons is scheduled to be deployed in mid-FY 2000, with the launch of the first Russian Soyuz spacecraft to ISS. From that point forward, a U.S. citizen will permanently reside on the ISS beyond the confines of earth. Microgravity capability will be available in late FY 2000, with the outfitting of the U.S. laboratory. At completion of this phase in late-FY 2000, the Station configuration will include Unity (the first U.S. node), Destiny (the U.S. laboratory), pressurized mating adapters, power, airlock, multi-purpose logistics module (MPLM); Zarya, the Russian service module, a Soyuz capsule, and the Space Station remote manipulator system (SSRMS) provided by Canada.

The fundamental nature of living and working in the isolated realm of space will change dramatically as the Program moves into and through the last phase of the program, which will see completion of assembly in the 2005 timeframe. During this period, the number of crew on orbit will increase to six members, with an associated increase in crew time for research. The number of payload research racks will increase from 3 to 38 racks, with experiment power availability for payloads increasing from 10 watts to over 40 watts. By the end of FY 2002 the Station configuration will include the U.S. Laboratory, truss segments, three solar arrays, and resupply/support vehicles. By the end of FY 2003, the second U.S. node, the Japanese Experiment Module (JEM), the Japanese Logistics Module (JLM), and the U.S. propulsion module are to be deployed, as well as the Science Power Platform (SPP). By the end of FY 2004 the Station configuration will include the Columbus Orbital Facility (COF, ESA's pressurized module), the Japanese Exposed Facility (JEF), a Russian research module, the Russian Docking and Stowage Module (DSM), the third U.S. Node, and the Cupola. A flight to outfit the third U.S. node will mark the beginning of the permanent 6-member crew capability. Delivery of the fourth solar array, the Centrifuge Accommodation Module, and the habitation module in FY 2005 will signal the initiation of the permanent 7-member crew capability. Implementation of these permanent crew capabilities will be dependent on adequate crew return capabilities. Routine logistics module launches to the Space Station will continue over the remaining life of the Station.

Due to the late October 1999 Proton failure and the extended duration of the resulting investigation, the launch schedule for FY 2000 and subsequent years remains somewhat uncertain. While the next ISS launch, the Russian Service Module, is on a path to resolve remaining test anomalies early in 2000, the actual schedule launch will likely be dependent on recommendations resulting from the Proton investigative teams. This will result in at least a four month delay from the current baselined assembly sequence, which is roughly commensurate with delays introduced from 1999 Shuttle wiring inspections and corrective action, as well as

slippage in U.S. ISS integration, test and verification activities. As a contingency against a delay of the Service Module in excess of four months, the program is reviewing the possibility of flying an interim mission in mid-FY 2000, using the Shuttle to perform critical services and activities. A firm launch date for the Service Module is expected to be set following reviews in February 2000.

The approach in this budget justification is to reflect the baselined assembly sequence (Revision E) for intermediate milestones for Vehicle Development, Research, and Russian Program Assurance, reflecting the program plan to maintain development/on-dock milestones in order to mitigate contractor cost growth. Launch dates in these sections are listed for Revision E, and a second target that reflects the current assembly planning sequence (11/12/99). The intermediate milestones and launch dates in the Operations Capability section, however, have been adjusted to reflect the current assessment (11/12/99) that includes a four month slip to the Revision E assembly schedule.

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE STATION VEHICLE

	FY 1999	FY 2000	FY 2001
	(Thousands of Dollars)		
Flight hardware	1,026,000	716,400	401,500
Test, manufacturing and assembly	134,500	122,900	38,700
Transportation support	23,400	50,800	2,400
Total	1,183,900	890,100	442,600

PROGRAM GOALS

Vehicle development of the International Space Station (ISS) provides an on-orbit, habitable laboratory for science and research activities, including flight and test hardware and software, flight demonstrations for risk mitigation, 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. The Japanese, ESA, and Russia will provide laboratory modules. Canada will provide a remote manipulator system, vital for assembly and maintenance of the station. The Russian Aviation and Space Agency (Rosaviakosmos) 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 and Japan. 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 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 and a cupola to the U.S. Node 2 is currently manifested for flight during the first quarter of FY 2003, the Cupola is manifested for flight during the second quarter of FY 2004, and Node 3 is manifested for flight during the third quarter of FY 2004. 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 funded the 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.

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 traceability, 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)
- Performed SIR 4 for flights through 4R (1st Qtr FY 1999)
- Performed SIR 5 for flights through UF-2 (1st Qtr FY 2000)
- Perform SIR 6 for flights through 9A.1 (2nd Qtr FY 2000)
- Perform SIR 7 for flights through 13A (4th Qtr FY 2000)
- Perform SIR 8 for flights through 10A.1 (2nd Qtr FY 2001)
- Perform SIR 9 for flights through UF3 (3rd Qtr FY 2001)

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:

Initial U.S. pressurized element, launched with PMA-1, PMA-2, and 1 stowage rack; PMA-1

Unity (Node 1),
Pressurized Mating Adapters (PMA-1, PMA-2)
Planned (Rev B): Dec. 1997
Revised (Rev D Mod): Dec.1998
Completed December 1998

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
Completed June 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
Revised (Rev E): 1st Qtr FY 2000
Revised Target: 3rd Qtr FY 2000

Double Spacehab flight for logistics/resupply during early assembly. Also delivers Crew Health Care Systems hardware with which to outfit the service module

- Delivery of TVIS for integration into Spacehab (4th Qtr FY 1999)
- Delivery of Strela Crane and components (1st Qtr FY 2000)
- Spacehab turnover to KSC (1st Qtr FY 2000)
- ICC Hardware Integration (1st Qtr FY 2000)
- Launch Flight 2A.2 (3rd Qtr FY 2000)

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
Revised (Rev E): 2nd Qtr FY 2000
Revised Target: 3rd 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)
- 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 antenna on dock at KSC (3rd Qtr FY 1998)
- S-Band antenna on dock at KSC (3rd Qtr FY 1998)
- Z1 flight unit completed and shipped to KSC (3rd Qtr FY 1998)
- Plasma Contactor and DDCU-HP Qualification Testing complete (4th Qtr FY1999)
- 3A MEIT complete (2nd Qtr FY 2000)
- Complete Z1 final outfitting (2nd Qtr FY 2000)
- Launch of flight 3A (3rd Qtr FY 2000)

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
Revised (Rev E): 2nd Qtr FY 2000
Revised Target: 4th Qtr FY 2000

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

- Beta Gimbal Assembly to P6 Integration (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)
- Radiator Qualification Testing complete (2nd Qtr FY 1999)
- Solar Arrays on-dock KSC (2nd Qtr FY 1999)
- Flight Radiators delivered to P6 Outfitting (1st Qtr FY 2000)
- 4A MEIT complete (2nd Qtr FY 2000)
- Launch flight 4A (4th 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
Revised (Rev E): 3rd Qtr FY 2000
Revised Target: 4th Qtr FY 2000

Launch of the U.S. Laboratory Module establishes initial U.S. user capability; launches with 5 system racks pre-integrated; KU-band and CMGs are activated.

- Complete installation of 5A/6A Racks in Lab for testing (3rd Qtr FY 1998)
- Lab on dock at KSC (1st Qtr FY 1999)
- Lab Acceptance Testing Complete (1st Qtr FY 2000)
- Deliver Command and Control and Guidance Navigation and Control Software to Lab (1st Qtr FY 2000)
- Complete 5A MEIT (2nd Qtr FY 2000)
- Launch of flight 5A (4th Qtr FY 2000)

Flight 5A.1:

Continues the outfitting of the U.S. Lab, with the launch of 6 system racks. This flight also

MPLM flight module-1, 6 Lab System Racks, 1 Payload Rack Planned: 2nd Qtr FY 2000 Revised (Rev E): 3rd Qtr FY 2000 Revised Target: 1st Qtr FY 2001	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) • Integration of HRF Sub-racks into the HRF rack (4th Qtr FY 1999) • HRF rack on-dock at KSC (2nd Qtr FY 2000) • Early Ammonia Servicer On-Dock KSC (2nd Qtr FY 2000) • MPLM Rack Installation/Closeout (3rd Qtr FY 2000) • Launch of 5A.1 (1st Qtr FY 2001)
Flight 6A: MPLM flight module-2, Canadian Remote Manipulator System, UHF Planned (Rev B): January 1999 Revised (Rev D Mod): 3rd Qtr FY 2000 Revised (Rev E): 4th Qtr FY 2000 Revised Target: 1st Qtr FY 2001	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; delivers Canadian SSRMS needed to perform assembly operations of later flights. • SSRMS On-dock KSC (3rd Qtr FY 1999) • Complete Integration and Test of MPLM FM2 (4th Qtr FY 1999) • MPLM FM2 On-dock KSC (4th Qtr 1999) • SSRMS and RWS Software complete (2nd Qtr FY 2000) • 6A MEIT Complete (2nd Qtr FY 2000) • MPLM Rack Integration / Closeout (3rd Qtr FY 2000) • Launch of flight 6A (1st Qtr FY 2001)
Flight 7A: Airlock, HP Gas Plan (Rev B): April 1999 Revised (Rev D Mod): 4th Qtr FY 2000 Revised (Rev E): 4th Qtr FY 2000 Revised Target: 2nd Qtr FY 2001	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. • Completed Airlock Integration/A&CO (2nd Qtr FY 1999) • Airlock System Software Complete (2nd Qtr FY1999) • Element level testing complete (1st Qtr FY 2000) • Airlock on dock at KSC (1st Qtr FY 2000) • Complete SLP integration (2nd Qtr FY 2000) • Launch flight 7A (2nd Qtr FY 2001)

Flight 7A.1
MPLM, SLP pallet
Planned (Rev B): Nov. 1999
Revised (Rev D Mod): 4th Qtr FY 2000
Revised (Rev E): 1st Qtr FY 2001
Revised Target: 2nd Qtr FY 2001

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.

- Hardware and schedule for this flight is currently undergoing replanning.

Flight 8A:
S0 Truss, Mobile Transporter,
Plan (Rev B): June 1999
Revised (Rev D Mod): 2nd Qtr FY 2001
Revised (Rev E): 2nd Qtr FY 2001
Revised Target: 3rd 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 flight fabrication, assembly, and outfitting (3rd Qtr FY 1999)
- S0 on dock at KSC (3rd Qtr FY 1999)
- Complete S0 STA Testing (4th Qtr FY 1999)
- Complete Mobile Transporter flight article (4th Qtr FY 1999)
- Command and Control Software Complete (3rd Qtr FY 2000)
- 8A MEIT Complete (1st Qtr FY 2001)
- Launch flight 8A (3rd Qtr FY 2001)

Flight 9A:
S1 Truss, CETA Cart
Plan (Rev B): September 1999
Revised (Rev D Mod): 3rd Qtr 2001
Revised (Rev E): 4th Qtr FY 2001
Revised Target: 1st Qtr FY 2002

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 (4th Qtr FY 1998)
- Radiators complete for S1 Integration (2nd Qtr FY 2000)
- Complete S1 STA testing (2nd Qtr FY 2000)
- Complete S1 flight Outfitting and Acceptance Testing (2nd Qtr FY 2000)
- S1 on dock at KSC (1st Qtr FY 2000)
- 9A MEIT Complete (1st Qtr FY 2000)
- Launch flight 9A (1st Qtr FY 2002)

Flight 11A: P1 Truss (3 Radiators), TCS, CETA, and UHF Band Communications Plan (Rev B): January 2000 Revised (Rev C): 1st Qtr FY 2001 Revised (Rev E): 4th Qtr FY 2001 Revised Target: 2nd Qtr FY 2002	P1 truss provides permanent active thermal control capability. Crew and Equipment Translation Aid (CETA) cart provides EVA crew translation capability along the truss. • Radiators complete for P1 Integration (2nd Qtr FY 2000) • P1 on dock at KSC (2nd Qtr FY 2000) • Complete P1 flight Acceptance Testing (3rd Qtr FY 2000) • CETA Cart Ready for P1 Integration (3rd Qtr FY 2000) • Pump Module ready for P1 Integration (3rd Qtr FY 2000) • 11A MEIT Complete (1st Qtr FY 2001) • Launch flight 11A (2nd Qtr FY 2002)

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) • Delivered GPS Receiver/Processor (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1999)
Extra-Vehicular Activity System	Provides Government Furnished Equipment (GFE), EVA unique tools, 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. • Delivered Crew Equipment Transfer Aid (CETA) Cart proto-flight unit (slip from 1st Qtr FY 1997 to 1st Qtr FY2000) • Delivered EVA Tool Storage Device (ETSD) for CETA Cart (1st Qtr FY 1998) • Delivered ETSD for airlock (1st Qtr FY 1998) • Delivered canisters for the Regenerable CO_2 System (3rd Qtr FY 1998) • Delivered 1st Flight Regenerator for the Regenerable CO_2 System (3rd Qtr FY 1998) • ORU Transfer Device (OTD) flight unit delivered (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)
- Completed production of tools and diagnostic flight hardware kit (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998)
- Completed Personal Hygiene Kit PRR Preliminary/Program Requirements Review (2nd Qtr FY 1998)
- Delivered 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.

- Delivered Qual hardware to airlock test article (Slip from 2nd Qtr FY 1997 to 2nd Qtr FY 1999)
- Final Flight Unit Deliveries (2nd Qtr FY 2000)

ACCOMPLISHMENTS AND PLANS

FY 1999 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) for the Russian Strela (cargo crane) are required to transport certain Spares and supplies, and to enable EVA operations. Flight 2A.1 was launched on May 27, 1999.

- 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 cargo to be flown includes internal and external spares and supplies, as well as station outfitting equipment.

- In preparation for flight 3A, Z1/P6 integrated testing was completed in the 4th quarter of FY 1998. The Z1 truss segment has completed the first phase of Multi-Element Integrated Testing (MEIT) in January 1999; the final phase was completed in the third quarter of FY 1999. Final flight software verification will be completed in the 1st quarter of FY 2000, and launch package integration should begin early in the 2nd quarter of FY 2000.

- 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. The first phase of P6 MEIT was completed in January 1999, and the final phase completed in the 3rd Qtr of FY 1999. Integrated flight software verification commenced in July 1999, and is scheduled for completion early in the 1st quarter of FY 2000.

- Flight 5A, U.S. Lab MEIT continues and is scheduled to be completed in the second quarter of FY 2000. Flight 5A/5A.1 racks have been installed, and remaining Lab testing at KSC is scheduled to be completed in the third quarter of FY 2000.

- 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. The Human Research Facility (HRF) Rack, which represents the first utilization of the ISS for science/experiments, has completed the integration of it's Sub-racks and is scheduled to be delivered to KSC in the second quarter of FY 2000.

- The MPLM used on flight 6A is the second flight unit to be built. The structure for this unit was completed early in FY 1999, and the completed unit was delivered to KSC in August of 1999. The SSRMS, which also flies on flight 6A, is scheduled to complete MEIT in the 2nd Qtr of FY 2000. 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 are scheduled to be integrated into the MPLM in the 2nd Qtr of FY 2000.

- The airlock, which flies on flight 7A, completed its Structural Static Test in early 1998. Airlock assembly and checkout was completed in the 2nd Qtr of FY 1999. The airlock system racks were completed in FY 1998 and were integrated into the airlock for element level testing in February 1999. Delivery of the Airlock to KSC is planned for mid December 1999.

FY 2000 activities will focus on the deployment of the U.S. Laboratory, renewed development of the U.S. Habitation Module, and the start of on-orbit research with the establishment of a three-crew presence capability. All major items of flight hardware required through Flight 8A, except the Airlock, have been delivered to KSC and are undergoing various levels of integration, test, and acceptance. Specific activities for FY 2000 include:

- Flight 2A.2, planned to be launched in the 3rd quarter of FY 2000, will deliver pressurized and external logistics to aid in station assembly and to prepare for crew-tended operations.

- Flight 2R, launches a Soyuz crew transfer vehicle, providing the Space Station with three-person human permanent presence capability. This flight has been delayed pending the resolution of the Proton vehicle problems.

- Flight 3A, scheduled for the 3rd quarter of FY 2000, will deliver the Z1 truss, control moment gyros, Ku and S-Band communications equipment, EVA support equipment, and PMA-3. This will enable essential station utilities to be integrated on subsequent flights.

- Flight 4A activities in FY 2000 include the final integrated test of major sub-systems including the Early External Active Thermal Control System (EEATCS) and Photovoltaic (PV) Arrays. The launch of Flight 4A in 4th quarter of FY 2000 completes the initial power and thermal requirements for crew-tended operations.

- U.S. Lab MEIT is scheduled for completion in the 2nd quarter of FY 2000, with delta acceptance testing planned to begin in the 2nd quarter of FY 2000. The Lab launch is planned for the 4th quarter giving the ISS the capability to support initial on-orbit research. Flight 5A.1, planned for the 1st quarter of FY 2001, will outfit the lab with systems racks to support assembly phase research, using the first of three Italian-built MPLMs.

- Development of the U.S. Habitat Module has been delayed while alternative concepts were investigated. The Hab Module PDR is planned for the 2nd Qtr of FY 2001, with CDR expected in mid-FY 2002. Delivery of the Hab will support the expansion of the station crew size to 7 at Assembly Complete.

- Other major flight hardware deliveries scheduled for FY 2000 include the truss segments for flights 11A (P1), 12A (P3/P4), and 13A (S3/S4).

- Completion of 3 of the 4 Multi-Element Integrated Test (MEIT) conditions for flight elements required for assembly flights 8A through 12A.

FY 2001 will see the finish of Phase 2 and the start of Phase 3 of the ISS assembly sequence, and the beginning construction of the middle truss on the station's backbone (Z1 Truss) launched the previous year. Two Utilization Flights and one outfitting / logistics flight will enable a broader range of research to be conducted as ISS assembly continues. Activities in preparation for these flights include:

- Flight 6A will complete U.S. Lab outfitting for Phase 2 of ISS assembly. Flight 6A also delivers the robotic arm, which is essential to continued assembly of the ISS. The SSRMS will complete MEIT and be integrated onto the SLP in the 1st quarter of FY 2001.

- The second US flight planned for FY 2001, Flight 7A, will carry the Airlock. Once installed, the airlock will provide the station an independent EVA capability, and will bring to a close Phase 2 of ISS assembly.

- Completion of 3 of the 4 Multi-Element Integrated Test (MEIT) TC1 & 2 and begin TC3 for flight elements required for assembly flights 10A – UF3.

- Commence final integration and testing of truss segments P3/P4 and S3/S4 with their solar arrays to complete construction of the middle truss in FY 2002. The truss segments are also configured for flight in FY 2001.

- Integrated Systems Testing of Node 2 to support a 1st Qtr FY 2003 launch.

- Demonstration of station-based EVA to support up to 30 hours of EVA from the U.S. Airlock each year.

- Conduct permanent on-orbit operations, providing an estimated 8,000 hours of ISS crew support to station assembly, operations, and research.

- Complete fuel transfer systems modifications in two orbiters to provide a station reboost capability of 5-6 nautical miles per Shuttle flight.

- Launch assembly flight 8A, which will carry the S0 truss segment, SSRMS mobile transporter, and the global positioning system.

- Launch 2 Utilization Flights carrying the Microgravity Science Glovebox, refrigerator/freezer racks, the Window Observation Research Facility (WORF-1), and additional payloads for the Human Research Facility (HRF-1).

- Complete Propulsion module fabrication and assembly, and conduct qualification testing. Perform a Hot Fire test in the second quarter of FY 2001 to support a launch in the fourth quarter of FY 2002.

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE STATION OPERATIONS CAPABILITY

	FY 1999	FY2000	FY 2001
	(Thousands of Dollars)		
Operations capability & construction...	83,000	49,100	22,500
Vehicle operations	258,600	454,500	432,300
Ground operations	234,700	260,000	371,700
[Construction of Facilities included]	[1,200]	[--]	[--]
Total	576,300	763,600	826,500

PROGRAM GOALS

The primary objective of the operations program is to safely and reliably deploy to orbit, assemble and operate the ISS, which requires a significant level of supporting ground operations such as crew and ground controller training and extensive planning activities. Starting years in advance of the final acceptance and launch of various ISS elements, transition of the International Space Station (ISS) vehicle program to the operations program is taking place. Sparing and logistics planning and procurements, element specific operations and anomaly preparation, and detailed integration of all capabilities and constraints of elements and ground systems are occurring across the partnership so the pieces and people operate as one system. The second major goal is to perform 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.

The first crew is to embark to ISS in FY 2000, setting in motion a progression of international crews which will allow humankind to permanently move aboard the ISS, beyond the confines of Earth. The program is preparing to furnish the crew with what is needed for them to live and productively work in the isolated and harsh environment of space for 24 hour a day, 365 days per year. This is the first time since the Skylab era in the 1970’s, and the Shuttle-Mir program, that the U.S. will have an extended human presence in space. Because of its massive size and level of international participation, the ISS assembly period will span half a decade, with ISS infrastructure and logistics deployed over multiple flights from launch vehicles across the globe. Because of the program’s complexity, the Space Station team has done extensive planning for operations of many different ISS vehicles on orbit. Each time an element is added to the current station, the flight characteristics and internal systems change, and the ISS stack on-orbit becomes essentially a different vehicle with different thermal constraints, drag coefficients, and other characteristics. The Space Station Program will draw on the experience derived from Skylab, the Shuttle-Mir program, and that gained from operating the Space Shuttle for nearly two decades to address the unique circumstances of building and operating an ever changing ISS vehicle. With each successive docking of an ascent vehicle to the ISS and the transfer of its contents to the ISS, and with each increment of operations, the Program will evaluate its methods and lessons learned to develop even more efficient and effective operations.

STRATEGY FOR ACHIEVING GOALS

The Space Station operations concept emphasizes multi-center and multi-program cooperation and coordination. Operations capability development and construction provides a set of facilities, systems, and capabilities to conduct the operations of the Space Station. For the U.S. segment, the work will primarily 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. Mission Control Center-Houston was completed for supporting the first two missions of the ISS. As ISS partners become operational, their respective ground operations functions are integrated by NASA into the unified command and control architecture, like that which has already occurred for Mission Control Center-Moscow (MCC-M) located in Kaliningrad. Beyond ISS specific operations, a consolidated approach between Space Shuttle and Space Station minimizes duplicated effort and costs for command and control, as well as training at JSC, where the initial Space Station Training Facility capability is now operational and the first crews are currently in training. Utilizing lessons learned from Shuttle-Mir, ISS crew training is knowledge and proficiency-based rather than timeline and detailed procedures based, as has been the case for the Shuttle crews.

Space Station vehicle operations provides systems engineering and integration to sustain the 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 continue to be consolidated and performed 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. The current unified command and facility 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, NASA will integrate their respective ground operations functions 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 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 Neutral Buoyancy Lab (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 also 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 (2nd Qtr FY 2000)
- SSTF Final RFT for flight 5A (3rd Qtr FY 2000)
- SSTF Initial RFT for Flight 5A.1 (2nd Qtr FY 2000)
- SSTF Final RFT for Flight 5A.1 (3rd Qtr FY 2000)
- SSTF Initial RFT for flight 6A (3rd Qtr FY 2000)
- SSTF Final RFT for flight 6A (4th Qtr FY 2000)
- SSTF Initial RFT for flight 7A (3rd Qtr FY 2000)
- SSTF Final RFT for flight 7A (1st Qtr FY 2001)
- SSTF Initial RFT for flight 7A.1 (4th Qtr FY 2000)
- SSTF Final RFT for flight 7A.1 (1st Qtr FY 2001)
- All RFT dates for flights beyond 7A.1 are template dates

Mission Control Center	Facility providing integrated command and control capabilities and support to real-time increment operations. • Mission Control Center ready to support use of ICM (2nd Qtr FY 2000) • Delivery to support flight 5A ISS Command and Control Capability (2nd Qtr FY 2000) • Complete backup control center (control center development complete) (3rd Qtr FY 2000)) • MCC Post Mariner Delivery (2nd Qtr FY 2000)
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 Actual: 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 And Requirements Document (IDRD) for Planning Period 3 Plan: May 1999 Revised Plan: February 2000	Baselining the ISS increments in the Increment Definition and Requirements Document officially initiates increment specific Product and training Development. This typically occurs at 12 months in advance of the first increment's operations. Planning Period 3 includes increments 3-5.
Integrated Planning System Final Development Release Plan: September 1999 Actual: November 1999	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	Formal program review of integrated operations planning product development

Plan: Sept 1999 Revised Plan: February 2000	
Baseline Increment Definition And Requirements Document (IDRD) for Planning Period 4 Plan: May 1999 Revised: July 2000	Baselining the ISS increments in the Increment Definition and Requirements Document officially initiates increment specific Product and training Development. This typically occurs at 12 months in advance of the first increment's operations. Planning Period 3 includes increments 6-9.
Conduct Increment Operations Review for Increment 2 Plan: Dec 1999 Revised: March 2000	Formal program review of integrated operations planning product development
Conduct Increment Operations Review for Increment 3 Plan: March 2000 Revised: July 2000	Formal program review of integrated operations planning product development
Conduct Increment Operations Review for Increment 4 Plan: November 2000 Actual:	Formal program review of integrated operations planning product development
Conduct Increment Operations Review for Increment 5 Plan: May 2001 Actual:	Formal program review of integrated operations planning product development
Crew Assigned for Increment 5 Plan: November 1999 Revised Plan: March 2000 Actual:	Official announcement of Expedition Crew for Increment
Crew Assigned for Increment 6 Plan: April 2000 Actual:	Official announcement of Expedition Crew for Increment
Publish MIM FY99 Plan: May 1999 Actual: June 1999	Annual update of the multi-increment manifest (MIM) covering Program multi-lateral vehicle traffic and crew rotation plan through the assembly period.

Publish MIM FY00 Plan: April 2000 Actual:	Annual update of the multi-increment manifest (MIM) covering Program multi-lateral vehicle traffic and crew rotation plan through the assembly period.
Publish MIM FY01 Plan: April 2001 Actual:	Annual update of the multi-increment manifest (MIM) covering Program multi-lateral vehicle traffic and crew rotation plan through the assembly period.

ACCOMPLISHMENTS AND PLANS

FY 1999

The first two ISS elements were successfully launched and mated during the first quarter of FY 1999. The Zarya control module, or Functional Cargo Block (FGB), was launched on November 20, 1998, by a Russian Proton Rocket from the Baikonur Cosmodrome, in Kazakstan. The FGB is an unpiloted space “tugboat” that provides early propulsion, power, and control capability and communications for the station’s first months in orbit. It also provides rendezvous and docking capability to the Service Module. The FGB was built by Russia under contract to the U.S., and is owned by the U.S. The Unity connecting module (Node 1) with two Pressurized Mating Adapters (PMA1 and PMA2) were launched from the Kennedy Space Center on December 4, 1998 aboard the Space Shuttle Endeavor. This was the first of 37 planned Space Shuttle flights to assemble the station. Unity is a six-sided connector for future station components. On December 6, 1998, Endeavor’s crew rendezvoused with Zarya, and, using a PMA-1, attached Unity and Zarya together. PMA-2 provides a Shuttle docking location. Eventually, Unity’s six ports will provide connecting points for the Z1 truss exterior framework, the U.S. Lab, the airlock, the cupola, Node 3 and the MPLM. The crew finished connecting the two elements during three subsequent spacewalks, and also entered the interior of the fledgling ISS to install communications equipment and complete other assembly work. The two elements are operating nominally in an orbit approximately 250 miles above Earth, with some maintenance required. The Mission Control Center was ready with all the software and hardware needed to support flight 2A in the first quarter of FY 1999. 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. Interface testing between the Mission Control Center - Houston (MCC-H) and the Mission Control Center-Moscow (MCC-M) was complete in late FY 1999. MCC-H and flight control team supported Flight 2A (December 1998) and Flight 2A.1 (May 1999). The Shuttle Discovery was launched on May 27, 1999, and performed the first docking with the International Space Station on May 29, 1999. This was a logistics flight utilizing a Spacehab Double Cargo Module. The crew unloaded almost two tons of supplies and equipment for the station, and performed one spacewalk to install a U.S.-developed spacewalkers’ crane, the base of a Russian-developed crane, and other spacewalking tools on the station’s exterior for use by future assembly crews. Discovery fired its thrusters to reboost the station’s orbit and then undocked on June 3, 1999. The Space Station Training Facility was ready for Expedition 1 training in September 1999. Other major accomplishments in the SSTF include the delivery of training software for flights 2A.1, 2A.2, 3A, 4A. Assembly critical spares for flights through 12A.1 have been defined and are being manifested on appropriate shuttle flights. A new Logistics and Maintenance post production support contract was negotiated with Boeing. Station Program Implementation Plan (SPIP) documentation has been baselined, with international partner agreements. A new assembly sequence (Rev. E) was baselined in June 1999.

Launch site processing work supported launch site testing and launch of ISS flights 2A and 2A.1. Space Station operations at KSC supported the first four test configurations of MEIT. Planning and processing support for ISS 7A through UF-1 was 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 have been processed and on-orbit stowage planning for flights 2A through 5A have been worked. Nine Zero-G stowage racks were procured and installed into the Lab (flight 5A).

The Super Guppy aircraft transported the US Lab, S0 structural test article and flight element, airlock, and US Lab structural test article elements to various locations.

Sustaining engineering for FY1999 included providing engineering and technical support required to maintain the hardware post-DD250 for flights 2A - 7A. Real-time engineering support was provided to the following missions/stages and supported Progress launches: 1A/R, 2A, 1R and 2A.1. A remote real-time data access capability for in-home and office use was implemented. Sustaining engineering products for flights 2A -10A were 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 were refined. Bilateral agreements on sustaining engineering were baselined with Agenzia Spatiale Italiano (ASI), Rosaviakosmos, and CSA.

FY 2000

FY 2000 will see the initial operation of ISS with three person permanent crew. Space Station Operations will support U.S. missions 2A.2, 3A, 4A and 5A. It will also support Russian missions delivering the Service Module and sending the first crew to ISS, as well as 5 other Soyuz/Progress flights.

The Zvezda Service Module (SM) is now targeted for launch aboard a Russian Proton rocket from the Baikonur Cosmodrome in Kazakstan. The SM will be launched without a crew aboard and will dock with the orbiting ISS by remote control. In addition to early station living quarters, the SM will also provide life support, navigation, communications, guidance and propulsion to the new station. Flight 2A.2 is a logistics flight scheduled to be launched aboard the Shuttle Atlantis. Logistics and supplies will be transferred to the new space station, and astronauts will begin orbital checkout and setup of the new living quarters. In addition, a spacewalk will be performed to install the Russian Strela crane telescoping boom. The station will remain unpiloted after Atlantis undocks. Flight 3A will be launched aboard the Space Shuttle Discovery, and will include the Integrated Truss Structure Z1, PMA-3, the KU-band communications system, and Control Moment Gyros (CMG's). The first ISS crew, designated Expedition 1, will be launched aboard a Russian Soyuz spacecraft. This begins the permanent human presence in space aboard the ISS. This crew will remain aboard the ISS for 4 months before departing. The Soyuz will remain attached to the ISS to provide assured crew return capability without the Shuttle present. Flight 4A, launched aboard the Space Shuttle Endeavor, will deliver the Integrated Truss Structure element P6, a photovoltaic module and two radiators, thereby providing U.S. power and cooling. The S-band communications system will be activated for voice and telemetry. Flight 5A, launched aboard the Atlantis, carries Destiny, the U.S. Laboratory Module. Destiny will be launched with 5 system racks already installed. With the delivery of the electronics in the lab, the CMG's will be activated, providing electrically powered attitude control.

Space Station Training Facility will support crew and flight controller training for Flights 2A.2 through 8A. MCC-H will support flights 2A.2 through 5A. Primary real-time ISS vehicle control responsibility will be transferred from MCC-M to MCC-H on Flight

5A. MCC-H software loads will be delivered for 4A- UF-2. Standalone Payload Training Capability (PTC) will be ready for flight 5A.1 & the integrated PTC will be ready for flight UF-3.

Training for Expedition 1 and 2 will be completed in FY 2000. Expedition 1 will launch and be returned to earth with the launch of Expedition 2, which is scheduled for the 1st quarter of FY 2001. Training for Expeditions 3 and 4 will continue throughout FY 2000. Training for Expeditions 5, 6 and 7 will begin in FY 2000.

Launch site processing activities continue in support of launch site testing and launch of ISS flights 3A through 7A.1. Station operations will support regression testing for MEIT 1 (2A, 3A, 4A, 5A and 6A) and MEIT 2 (integrated truss elements) both 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 Provisional Item Orders (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, and 5A. 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.

FY 2001

In FY 2001 the ISS program will conduct the first full year of permanently crewed on-orbit operations. It will also be the first full year of U.S. leadership of the primary real time ISS vehicle control function. ISS will begin operations with contributions from additional international partners. The Canadian Space Station Remote Manipulator System (SSRMS) will be installed on the ISS, and the program will use the MPLM from Italy for the first time.

Early in the fiscal year, a Russian Soyuz rocket will launch the Docking Compartment (DC-1). This will provide additional egress, an ingress location for Russian-based spacewalks, and a Soyuz docking port. Flight 5A.1, launched aboard the Discovery, will ferry the Expedition 2 crew to the station and return the first crew to earth. It will carry Leonardo, the first Multi-Purpose Logistics Module (MPLM), with equipment racks to outfit the lab module. It will also deliver the first research rack, HRF #1. Flight 6A, launched aboard the Shuttle Endeavor, will carry Raffaello, the first Italian-built Multi-Purpose Logistics Module (MPLM), including six systems and two storage racks for the U.S. Lab. Also aboard are a UHF antenna to provide space-to-space communications capability for U.S.-based spacewalks, and the Canadian SSRMS (station mechanical arm) required to perform assembly operations on later flights. Flight 7A, launched aboard the Atlantis, will deliver the Joint Airlock and the High Pressure Gas Assembly. The former will provide station-based extravehicular capability for both U.S. and Russian spacesuits, while the latter will support spacewalk operations and augment the Zvezda Service Module gas resupply system. The addition of this hardware completes Phase II of the ISS, indicating that it has achieved a certain degree of self-sufficiency and capability without the presence of an orbiter. Four more flights will occur in FY 2001. Flight 7A.1 would use the Shuttle Endeavor to ferry the 3rd resident crew to the station. It would also carry an Italian-built MPLM module containing U.S. stowage racks and International

Standard Payload Racks (ISPR's). The second U.S. built spacewalkers' crane will be attached to the exterior of the station. UF-1, the first utilization flight, will utilize Atlantis, and will include an MPLM and PV Module Batteries. The MPLM will contain experiment racks for the U.S. Lab and two storage racks. Flight 8A, planned to be launched aboard the Endeavor during the early summer, carries the fourth resident crew and returns the second to earth. The center segment of the station truss, ITS S0, and the Canadian Mobile Transporter are also aboard. UF-2, a second utilization flight, is the last flight being planned for FY 2001. It will be launched aboard the Atlantis, and will carry an MPLM containing experiment racks and three stowage and resupply racks to the station. Also aboard will be the Mobile Base System, to be attached to the Mobile Transporter, thus completing the Canadian Mobile Servicing System (MSS).

Training for Expedition crews 3 and 4 will be completed. Expedition crews 2,3, and 4 will be launched to ISS and 1,2,and 3 will be returned. Training for Expedition crews 5, 6 and 7 will continue in FY 2001; they are scheduled to be completed in FY 2002. The training template suggests that Training for Expeditions 8-11 will begin in FY 2001. Space Station Operations will provide real time support to flights 5A.1, 6A, 7A7A.1, UF-1, 8A , UF-2, 9A and 11A. The program will also support 6-7 planned Progress flights and two Soyuz flights. IDRDs for planning periods in 2002 and 2003 will be baselined.

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE STATION RESEARCH

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Research Projects	191,200	246,200	337,100
Utilization Support	143,300	148,200	118,300
Mir Support (including Mir Research)	2,000	--	--
Total	336,500	394,400	455,400

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. The experience and knowledge gained from long-duration human presence on the ISS will help us learn how to more safely and effectively live and work in space. ISS will also provide 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 ISS 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 ISS 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 management of the ISS research and technology, science utilization, and payload development with the ISS development and operations program to enhance the integrated management of the total content of the ISS budget. The Space Station Program Manager is 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 ISS objectives, and funding the principle investigators. The budget reflects this consolidation by funding research capability development and Station–related Space Product Development activities within the ISS account. There is close coordination among the NASA science offices and the ISS program to ensure that the research capabilities provided by the ISS are tightly coupled to the needs of the various research communities it will serve.

In response to House Report 105-610, accompanying H.R. 4194, NASA submitted a report to Congress on September 17, 1999 outlining a plan for transitioning administrative authority for the ISS Research Program to OLMSA. The new Space Utilization and Product Development Division within OLMSA was designated to assume administrative authority over the research program for the HEDS Enterprise. It will be the principal interface with the Payloads Office located at the Space Station Program Office, Johnson Space Center. The transition will occur during FY 2000. No restructuring of the budget is envisioned.

NASA is currently evaluating options for a potential new facility at the Kennedy Space Center. Under one option, the Space Experiment Research and Processing Laboratory (SERPL) would be constructed in partnership with the State of Florida and would provide a world-class laboratory facility with the capability to host ISS experiment processing and biological and life sciences research. The State of Florida would provide the bulk of the funding required for such a facility, but NASA would also be responsible for a small portion of the initial design and facility construction costs. Any NASA facility funding requirements would be within existing and planned budgets of the Human Exploration and Development of Space (HEDS) Enterprise, and incurred in the FY 2000-FY 2002 timeframe.

NASA also delivered to Congress the Commercial Development Plan for the ISS during the first Quarter of FY 1999. Several independent marketing and management studies are currently underway. NASA is discussing several commercial opportunities with U.S. industry. Recently, the White House and Congress approved the "International Space Station Commercial Demonstration Program" initiative to establish a pricing policy for commercial use of ISS facilities in support of the commercial development of space.

The Revision E Assembly Sequence and research budget rephasing for FY 2000 – FY 2003 have impacted the planned research program. While still emphasizing early research capabilities, major payload facilities have been delayed on average about three to four months. The delivery schedule for research facilities continues to closely track the buildup of ISS accommodations to ensure the research programs ramp 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.

The STS-95 research mission was conducted during October 1999, and an additional research transition (STS-107) mission was added to the Shuttle manifest in early 2001 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 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.

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, NASA effectively doubled U.S. research crew time and stowage through our crewtime 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 development continue under the Implementing Agreement 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) and the microgravity science glovebox 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 Biomedical Research and Countermeasures, Gravitational Biology and Ecology, Microgravity Research, Space Products Development, Earth Observation Systems, and Engineering Technology) and Utilization Support.

Research Projects

Biomedical research facilities and activities include 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. 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 including 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 ISS 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.

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 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 Space Station Materials Science Research Facility (MSRF) 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.

The 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 ISS assembly sequence. A more mature Block 2 version will be provided by the Brazilian Space Agency as a subsequent upgrade.

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. In order to take advantage of related activities and expertise, the AHST projects have been merged with Engineering Research Technology.

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 AHST program activities merged into ERT will 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. This 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 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.

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 (PPS) 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 a generic architecture, which supports multiple programs including Space Shuttle and the Chandra X-Ray Observatory (CXO, formerly known as AXAF).

Utilization Support 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 also provides the necessary integration across all International Partner payload planning and operations to ensure efficient, compatible use of ISS 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 was 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 under development for the ISS 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 ISS research activities.

<u>SCHEDULE & OUTPUTS</u>

Research Projects

Centrifuge & Life Sciences Glovebox CDR Plan: Rotor 3rd Qtr FY 2001 LSG 4th Qtr FY 2000 Actual:	The Life Sciences Glovebox PDR was completed during late 1999. The Centrifuge Rotor PDR is scheduled for early 2000.
Fluids Combustion System PDR Plan: 4th Qtr FY 2000 Actual:	The FCF program was restructured and a Hardware Concept Review was conducted in FY 1998. A PDR is planned for FY 2000. The third rack of the FCF has been deferred until 2005.
Materials Science Research Facility Rack 1 CDR Plan: 4th Qtr FY 2000 Actual:	The SSFF project was renamed the MSRF, restructured and re-baselined in FY 1998. A PDR was completed during 1999. The CDR for the first rack will be held in late 2000.
CHeCS Complete manufacture and assembly of qualification hardware Plan: 3rd Qtr FY 1997 Actual: 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.
Human Research Facility Rack 1 CDR Plan: 1st Qtr FY 1999 Actual: 1st Qtr FY 1999	HRF Rack 1 subrack integration is complete. On-dock delivery to KSC is planned for early 2000 to support launch on 5A.1.
Gravitational Biology Facility Rack 1 Fab/Assy/Test Plan: 4th Qtr FY 2000 Actual:	The GBF Habitat Holding Rack 1 will begin Fabrication/Assembly/Testing during late 2000.
Biotechnology Facility PDR Plan: 3rd Qtr FY 2000 Revised 3rd Qtr FY 2001	The BTF has been deferred until 2005.
Materials Science Research Facility Rack 2 CDR	The 2nd and 3rd racks of the MSRF have been deferred until 2005.

Plan: 4th Qtr FY 2000
Revised: 1st Qtr FY 2003

Low Temperature Microgravity Physics Facility PDR
Plan: 2nd Qtr FY 2000
Actual:

The LMTPF completed a Conceptual Design Review during early 1999. A PDR is planned for mid 2000.

Human Research Facility Rack 2 CDR
Plan: 2nd Qtr FY 2000
Actual:

The HRF Rack 2 will complete a CDR and begin Fabrication/Testing during FY 2000.

Utilization Support

EXPRESS Racks 1 & 2 Final Testing and Reviews
Plan: 2nd Qtr FY2000
Actual:

Structural buildup, final documentation, safety reviews and testing are in work. Subrack integration and final testing for the first 2 racks will be completed in early 2000. The first two EXPRESS Racks will be on-dock at KSC during mid 2000.

Complete POIC/USOC and facilities outfitting
Plan: 1st Qtr FY 2000
Actual:

Payload Operations Integration Center (POIC) and U.S. Operations Center (USOC) at MSFC will complete initial outfitting during early 2000.

EXPRESS Pallet PDR
Plan: 4th Qtr FY 1999
Actual:

Brazil is building the EXPRESS Pallets. The PDR has been delayed due to funding problems with the Brazilian Government.

Complete PP2 Baseline IDRD
Plan: 1st Qtr FY 1998
Actual: 1st Qtr 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 was baselined in November 1998.

WORF Block 1 CDR
Plan: 2nd Qtr 2000
Actual:

The Window Observational Research Facility (WORF) completed a Systems Requirement Review and Preliminary Requirements Review during 1999. A CDR is planned for early 2000.

Payload Crew Training
Plan: 1st Qtr FY1999
Actual: 1st Qtr FY 1999

Payload Crew training began during early 1999.

PDSS Initial Operations Capability
Plan: 2nd Qtr FY 1999

The capability to process Ku-band (payload) and S-band (core systems) telemetry data for the 5A.1 and subsequent missions was developed.

Actual: 2nd Qtr FY1999

Communications Link Activation
Plan: 2nd Qtr FY 2000
Actual:

The initial communication link activation from the Huntsville Operations Support Center (HOSC) to the Space Station Control Center (SSCC) to support payload training and operations occurred during the 3rd Quarter of FY1999. Full communication link activation is scheduled for mid 2000.

PPS Build 2
Plan: 1st Qtr FY2000
Actual:

The Payload Planning System (PPS) capabilities required to support Cadre-Payload Developer Training was completed during mid 1999. Build 2 is planned for early 2000.

ACCOMPLISHMENTS AND PLANS

Research Projects - FY 1999

Development of ISS facility-class payloads made significant progress during FY 1999. Three of five research racks were delivered in preparation for launch on 5A.1, 6A and 7A.1. The payload planning process was simplified to reduce documentation and risk. The development integration template was revised to reduce product delivery milestones and shorten integration timeframes. Detailed payload manifests were approved for 2000 and 2001.

Rack 1 of the Human Research Facility (HRF) completed a CDR during early in FY1999. Rack 1 subrack integration has been completed and the HRF is in final verification testing. The HRF and subrack level experiments will be delivered on-dock to KSC during early 2000 in preparation for flight on 5A.1. Rack 2 of the HRF has been accelerated to fly on 12A.1. Flight units of the following hardware were delivered: ultrasound, GASMAP, computer workstation. The HRF Flight Prototype Rack was included in the MEIT at KSC in mid-FY 1999. The test verified the ISS interfaces (electrical, thermal, communications, data, etc.), ISS payload test tools, and HRF integration tools.

The Microgravity Science Glovebox completed a CDR during in early FY1999 and continues in Fabrication/Assembly/Testing in preparation for launch on UF-1. The Microgravity Science Glovebox Ground Unit was delivered to MSFC in late FY1999. The Minus Eighty-Degree Laboratory Freezer completed a CDR and initiated Fabrication/Assembly/Testing in preparation for launch on UF-1.

The Fluids and Combustion Facility (FCF) Combustion Integrated Rack completed a PDR and a Phase 1 Safety Review. The FCF Fluids Integration Rack continued in the design phase. The 3rd rack of the FCF was deferred until 2005

The Microgravity Science Research Facility (MSRF) Experiment Carrier completed a PDR. The MSRF Racks 2 and 3 were deferred until 2005. The Biotechnology Facility was also deferred until 2005.

The Life Sciences Glovebox completed a PDR and a KC-135 mock-up test to evaluate glovebox operations. The Centrifuge Rotor PDR was rescheduled for 2000. The Gravitational Biology Facility (GBF) continued build-up of the qualification hardware. The GBF Habitat Holding Rack 1 and Cell Culture Units continued in detailed design. The GBF Biomass Production System and Avian Development Facility continued in Assembly/Testing in preparation for launch on UF-1 and UF-2.

The Low Temperature Microgravity Physics Facility completed a Conceptual Design Review. The Stratospheric Gas and Aerosol Experiment (SAGE III) completed an instrument CDR and continued in Assembly/Testing. The Hexapod pointer system completed a PDR. In addition, flight instruments assembly and subsystem testing were initiated during 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 completed a PDR for the Optical Communications Demonstration (OCD) project. The Attitude Control and Energy Stowage Experiment (ACESE) project was restructured and renamed the Flywheel Energy Storage System (FESS) and continued in Assembly/Testing.

Research Projects - FY 2000

During FY 2000, NASDA will complete the Life Science Glovebox CDR and initiate Fabrication/Assembly/Testing. The Centrifuge Rotor Facility will complete a PDR and continue detailed design. The GBF Habitat Holding Rack 1 will initiate Fabrication/Assembly/Testing. The GBF Cell Culture Unit will conduct a CDR, the Advanced Animal Habitat a PDR, and the Plant Research Unit a PRR. The GBF Biomass Production System and Avian Development Facility will continue Assembly/Testing in preparation for launch on UF-1 and UF-2.

The HRF Rack 1 will be delivered on-dock to KSC in preparation for launch on 5A.1. The HRF Flight Prototype Rack will be included in the MEIT End-to-End Test in early 2000. This test will include full end to end flow of commands and telemetry to HRF in the U.S. Lab from the Telescience Center. The HRF Rack 2 will complete a CDR and initiate Fabrication/Assembly/Testing.

The Microgravity Sciences Glovebox and Minus Eighty-Degree Laboratory Freezer (MELFI) will continue in Fabrication/Assembly/Testing in preparation for launch on UF-1.

The FCF project activities planned for FY 2000 include a Fluids Integration Rack CDR and Phase 1 Safety Review. The Combustion Integrated Rack will complete a CDR, Phase 2 Safety Review and continue manufacturing/assembly.

The MSRF Rack 1 will complete a PDR, CDR and initiate Fabrication/Assembly/Testing. The MSRF Experiment Carrier and Inserts will complete CDRs. The Biotechnology Facility will conduct a Requirements Design Review. EXPRESS Rack level biotechnology and fluid physics payloads will be launched on 6A and 7A.1.

The Low Temperature Microgravity Physics Facility will complete a PDR, CDR and initiate Fabrication/Assembly/Testing in preparation for launch on UF3. The SAGE III and Hexapod units will conduct CDRs and continue Fabrication/Assembly/Testing.

The Engineering Research Technology Program will conduct a CDR and initiate Fabrication/Assembly/Testing for the OCD project. FESS will complete a PDR and continue in Assembly/Testing. PDR reviews will be conducted for the Flexible Control Structures; Photovoltaic Engineering Testbed and the Micron Accuracy Deployment Experiments. The Advanced Human Support Technology (AHST) facility will conduct a Requirements Design Review.

Research Projects – FY 2001

During FY 2001, the research program will maximize early research opportunities on the HRF Rack 1, Express Racks, Microgravity Sciences Glovebox and the Window Observational Research Facility. The program will also continue development activities on the remaining facility-class payloads.

The HRF Rack 2 will complete Assembly/Testing and be delivered on-dock to KSC in preparation for launch on 12.1.

The Life Sciences Glovebox will continue Fabrication/Assembly/Testing. The Centrifuge Rotor and GBF Advanced Animal Habitat will complete CDRs and initiate Fabrication/Assembly/Testing. The GBF Cell Culture Unit will continue in Assembly/Testing. The GBF Biomass Production System and Avian Development Facility will continue Assembly/Testing and be delivered to KSC in preparation for launch on UF-1. The GBF Habitat Holding Rack 1 will initiate Fabrication/Assembly/Testing.

The Microgravity Sciences Glovebox and Minus Eighty-Degree Laboratory Freezer (MELFI) will complete integration testing and KSC processing in preparation for launch on UF-1.

The FCF project and Fluids Integration Rack will complete CDRs. The Combustion Integration Rack will continue Fabrication/Assembly/Testing.

The MSRF Rack 1 will continue Fabrication/Assembly/Testing. The MSRF Experiment Carrier will initiate Fabrication/Assembly/Testing. The ISS Biotechnology Facility will complete a PDR. EXPRESS Rack level biotechnology and fluid physics payloads will continue operations in the EXPRESS Racks on the ISS.

The Low Temperature Microgravity Physics Facility will continue Fabrication/Assembly/Testing. The SAGE III and Hexapod units will continue Fabrication/Assembly/Testing.

The Engineering Research Technology Program will continue Fabrication/Assembly and Testing for the FESS and OCD projects; and conduct CDR reviews for the Photovoltaic Engineering Testbed and the Micron Accuracy Deployment Experiments. The Advanced Human Support Technology (AHST) facility will conduct a PDR.

Utilization Support - FY 1999

During FY 1999, preparations continued to ensure capabilities readiness to support on-orbit payload operations. Payload Crew Training was initiated for Expedition 2 Crew to support Increment 2 and 3 payloads on the HRF and EXPRESS Racks. A Payload Readiness Review was completed for flights 5A.1, 6A and 7A.1.

The Huntsville Operations Support Center (HOSC) and POIC were declared operationally ready to support 5A.1 and 6A payload operations. POIC internal simulations were conducted to support early payload operations. Many of the flight products were completed and integrated with the systems operations products. The first payload crew began training for the missions and the integrated engineering and operational assessments were performed for the payload complements. Development continued on the final operations capabilities of the PDSS, PPS, and PTC to support Flights 5A, 6A. Payload unique ICDs and verification plans were completed and Payload Integration Agreements were baselined.

An Operational Readiness Review (ORR) for the Telescience Support Center (TSC) was held at 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 Payload Checkout Unit (PRCU) facility mods were completed ahead of schedule and units were delivered to JSC, MSFC, GRC, and KSC.

During FY 1999, the first two EXPRESS Racks continued Assembly/Testing to support on-dock delivery to KSC in early 2000. Express Rack subsystem qualification was completed. Rack 1 Acceptance Testing was completed. The Active Rack Isolation ISS Characterization Experiment (ARIS ICE) continued preparation for launch on the second EXPRESS Rack. EXPRESS Rack trainer units were delivered to the Payload Training Facility. These units will be used for procedure development and crew training to support the 6A and subsequent flights. Subsystem hardware integration and verification were completed. EXPRESS Racks 3, 4 and 5 continued in Fabrication/Assembly/Testing.

A PDR for the EXPRESS Pallet scheduled for FY 1999 was delayed because of Brazilian funding problems.

The Window Observational Research Facility (WORF) completed its Systems Requirements Review and PDR.

Utilization Support - FY 2000

Expedition 2 and 3 Crews will continue payload training to support Increments 2, 3 and 4. Certificate of Flight Readiness Reviews (COFR) will be conducted for payloads planned for 5A.1, 6A, and 7A.1.

Express Rack 2 Acceptance Testing will be completed and the first two EXPRESS Racks will be delivered to KSC for launch on 6A. Subrack payload integration of Racks 1 and 2 will occur at KSC. Delivery, final testing, and subrack integration for the second two EXPRESS Racks will be completed for launch on 7A.1. EXPRESS Racks 6, 7 and 8 will initiate Fabrication/Assembly/Testing.

The Express Pallet program will complete its PDR.

The Window Observational Research Facility will complete a CDR and initiate Fabrication/Assembly/Testing.

Utilization Support – FY 2001

The payload operations facilities will continue to support on-orbit payload operations. Payload crew training will continue to support Increments 4, 5 and 6. Payload Readiness Reviews will be conducted to support assembly flights 8A – 9A.1.

The first four EXPRESS Racks will be on-orbit and conducting payload operations. The fifth EXPRESS Racks will complete final integration testing and KSC processing for launch on UF-2. Express Racks 6, 7 and 8 will continue Fabrication/Assembly/Testing.

The Express Pallet Program will complete a CDR and initiate Fabrication/Assembly/Testing.

The Window Observational Research Facility will be delivered on-dock to KSC to complete integration testing and KSC processing to support launch on UF-2.

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE STATION RUSSIAN PROGRAM ASSURANCE *

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Russian Program Assurance	203,000	200,000	300,000

* This assumes a $100M million reallocation from Vehicle funding in FY 1999 for Russian goods and services. NASA has not submitted to Congress the intended increase of $100 million for RPA for Operating Plan consideration, pending further discussions with Rosaviakosmos, the Russian Aeronautics and Space Agency. Currently, no payments are being made for Russian goods and services, pending appropriate resolution of Service Module delivery scheduling and Proton launch support.

PROGRAM GOALS

Russian Program Assurance (RPA) was established within the Space Station program to fund contingency activities and backup capabilities in response to concerns about the impact of potential delays or shortfalls in the Russian Government's 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 first quarter of FY 2000, with additional delays of at least four months due to recent Proton launch vehicle failures.

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 potential delays or shortfalls on the part of Russia in meeting its commitments to the ISS program, allowing the U.S to move forward with ISS assembly or operations in spite of potential shortfalls. These contingency activities are not intended to protect against the complete 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 more costly and less robust space station.

BACKGROUND

For several years Russia has experienced significant economic challenges resulting in the Russian Aviation and Space Agency (Rosaviakosmos) receiving only a fraction of its approved budget. These 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 to provide a backup capability in the event the Russian Service Module was significantly delayed or not successfully 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 additional contingency plans to provide flexibility for the United States in the event of further Russian delays or shortfalls. These consist primarily of building a U.S. Propulsion Module, enhancing logistics capabilities, modifying the Shuttle fleet for enhanced Shuttle reboost of ISS, and procurement of needed Russian goods and services to support Russian schedules for the Service Module and early ISS Progress and Soyuz launches.

STRATEGY USED FOR ACHIEVING PROGRAM GOALS

During summer 1998, NASA undertook additional efforts 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 capability will be obtained by modifying the Shuttle orbiters to permit the internal transfer of fuel from aft to forward tanks, so that the maximum amount of excess maneuvering propellant can be utilized by the Shuttle to reboost the ISS while it is docked. To further reduce U.S. reliance upon Russian contributions, NASA is proceeding with the development of a U.S. Propulsion Module that will provide permanent, independent reboost and attitude control. The Propulsion Module is being acquired from Boeing under the existing prime contract, and the development schedule calls for both the preliminary and critical design reviews to be completed in FY 2000.

In parallel to the development of the Propulsion Module, NASA has maintained a continuous dialogue with Rosaviakosmos representatives to fully understand their fiscal situation. The Administration and the Congress responded affirmatively to NASA's September 1998 recommendation to provide the Rosaviakosmos 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 Aviation and 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 Rosaviakosmos to maintain delivery schedules for the Service Module and other early Russian contributions. With the Service Module approaching its launch date, NASA intends to shift the focus of work on the Interim Control Module (ICM) to an alternate contingency plan. If the Service Module launch is successful, then the ICM will be reconfigured to provide an on-orbit back-up capability for the Service Module, in the event that Russian Progress resupply missions are disrupted.

To ensure the continuation of ISS assembly, including certainty regarding availability of Russian Progress and Soyuz, NASA's contingency planning includes the possible purchase of additional needed goods and services from Russia. NASA has conducted discussions with Rosaviakosmos regarding the purchase of Soyuz crew return services as well as the purchase of other needed hardware and services such as trainer mock-ups, EVA suit support, a docking mechanism for the Propulsion Module, a pressure dome for the ICM, and additional test and validation efforts for U.S./Russian flight software. The purchase of Soyuz services would enable deployment of six crew to orbit prior to the availability of a U.S. crew return capability. The baseline Russian commitment provides for Soyuz services for three crew. The deployment of six crew can be achieved with two Soyuz present on the ISS. The baseline of seven crew cannot be achieved without an operational U.S. crew return capability. These purchases would be provided with FY 1999 RPA funding being held for that purpose, pending resolution with Rosaviakosmos. Currently, no payments are being made for Russian goods and services, pending appropriate resolution of Service Module delivery scheduling and Proton launch support.

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 may determine that adjustments to funding for ISS activities may be warranted subject to changes in conditions with Russia. NASA will be prepared to provide some of the logistics requirements that Russia agreed to provide, should Rosaviakosmos be unable to provide critical logistics needs due to insufficient funding from their government. This could 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. This requirement is also included in the current RPA budget request. The International Space Station Intergovernmental Agreement and the bilateral Memorandum of Understanding between NASA and Rosaviakosmos provide the flexibility to modify Russian participation in the ISS Program through a rebalancing of partner contributions and benefits.

There is an additional possibility for U.S. backup capabilities in this budget request, for development of alternate access to space. Funding for alternate access is provided in the Advanced Space Transportation program with the Science, Aeronautics, and Technology appropriation request, and could result in a U.S. capability other than the Space Shuttle, to provide logistics services. Such capabilities could be purchased as commercial services, and might not only provide contingency capability against potential shortfalls, but could also be used to add flexibility to Space Station operations.

SCHEDULE & OUTPUTS

SM Launch Plan: December 1998 Revised: 4th Qtr FY 1999 Revised: 1st Qtr FY 2000 Revised: 2nd Qtr FY 2000 Revised Target: 4th Qtr FY 2001	• The SM will be launched as part of the ISS Revision E Assembly Sequence
Interim Control Module Plan: February 1999 Revised: Contingency	• Complete environmental testing in the flight configuration (1st Qtr FY 2000) • Deliver ICM to KSC (3rd Qtr FY 2000 – contingent on launch of the Russian Service Module) • Launch ICM on Flight 2A.3 (contingent on launch of the Russian Service Module)

Propulsion Module Plan: 4th Qtr FY 2002 Revised Target: 2nd Qtr FY 2003	• Complete Preliminary Design Review (1st Qtr FY 2000) • Complete Critical Design Review (3rd Qtr FY 2000) • Start structural test article assembly (4th Qtr FY 2000) • Conduct thruster hot fire tests (1st Qtr FY 2001) • Mate aft and mid Propulsion Module segments (3rd Qtr FY 2001) • Propulsion Module on-dock at KSC (2nd Qtr FY 2002) • Launch on Flight 10A.1 (2nd Qtr FY 2003)
Orbiter Interconnectivity Modifications Plan: 2nd Qtr FY 2001	• OV-103 modification complete (2nd Qtr FY 2001) • OV-105 modifications complete (3rd Qtr FY 2002)

ACCOMPLISHMENTS AND PLANS

FY 1999

RPA major activities included the completion of ICM development, continuation of work on orbiter fuel transfer modifications, and the initiation of Propulsion Module development. Activities accomplished include:

- ICM Shuttle Flight Definition Requirements approved in June 1999.
- ICM integrated flight configuration tests completed in September 1999.
- Propulsion Module System Requirements Review completed in April 1999.
- Propulsion Module/Shuttle Orbiter Propellant Transfer System Requirements Review completed in June 1999.
- Orbiter Interconnect Modification kit design completed in July 1999.

FY 2000

RPA Propulsion Module development will proceed at an accelerating pace. Depending on the results of the Russian Service Module launch, the ICM will be deployed either in its original configuration, or modified to provide a Service Module back-up capability. Initial procurements of Russian goods and services could start, along with the delivery of the first Orbiter interconnect modification kits. Specific activities include:

- ICM delivery to KSC for launch in response to Russian Service Module deployment.
- Propulsion Module Preliminary Design Review (1st Qtr FY 2000) and Critical Design Review (3rd Qtr FY 2000).

- Propulsion Module structural test article assembly (4th Qtr FY 2000).
- First installation of an Orbiter fuel interconnect mod kit (3rd Qtr FY 2000).
- Depending on the availability of Russian Progress vehicles, provisions may be made for U.S. resupply of pressurized logistics.

FY 2001

This year the Propulsion Module development will be nearing completion, the final delivery of Orbiter fuel interconnectivity mod kits will occur, and work on Russian goods and services will continue. Specific activities include:

- Conduct hot fire test of Propulsion Module thrusters (2nd Qtr FY 2001).
- Start final assembly and checkout of Propulsion Module flight segments (4th Qtr FY 2001).
- Complete delivery of Orbiter fuel transfer mod kits (3rd Qtr FY 2001).

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE STATION CREW RETURN VEHICLE

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Crew Return Vehicle	--	75,000	90,000

PROGRAM GOALS

The safety of the crew for the International Space Station is of critical importance. The Russian Soyuz provides 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 sole 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 three 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 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 Phase 1 Crew Return Vehicle (CRV) project will initiate work towards an independent U.S. crew return capability for the ISS for the life of the Station. The CRV would 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 reduce the risk of developing a CRV. The X-38 design has a strong foundation from the lifting body research and technology developments carried out since the 1960's. The transition from X-38 research and development to CRV design and development began in FY2000 as X-38 work phases out and CRV work phases in. The transition plan 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 November 99. Five companies are currently participating in this phase, which is being 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 mid- FY 2002. At the end of Phase 1 (approximately 2 years) the final build-to-specification configuration of an X-38-based CRV will have been established. The

government at the end of Phase 1 will own all drawings, prints, schematics, and software. The ISS CRV budget provides the funding for Phase 1 contractor activities in FY 2000-2002.
- Phase 2 - Currently planned as a production of four CRVs by industry. However, a decision on whether to proceed with an X-38-based CRV design will be made within two years, in the context of broader decisions that NASA and the Administration will make regarding future space transportation architectures. Funding for Phase 2 of CRV development currently resides in the SAT account, pending these decisions. Should the decision be made to proceed with the X-38-based CRV design, an amount up to the Phase 2 funds would be transferred from the SAT account, and a contractor would be selected by a competition based on the released drawings for the vehicle. In this case, Phase 2 funding is anticipated to be provided beginning in FY 2002.

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.

NASA plans to proceed with the completion of the X-38 Space Flight Test and the Phase 1 activities to maintain the CRV Program on a path intended to have a U.S. crew return capability on-orbit within approximately six months of the time the ISS achieves 6 person crew capability. During the period between achieving six person capability and the availability date of the U.S. crew return capability, NASA plans to use the Soyuz crew return services purchased from Russia (as described previously in the Russian Program Assurance budget justification) so that the ISS can operate at the six-person capability until the U.S. capability is available. When a U.S. crew return capability is available, and the habitation module is delivered, seven person crew capability will be achieved.

SCHEDULE & OUTPUTS

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 Actual: November 1999	Release RFP for a funded period in which two 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: 4th[rd] Qtr FY 2000	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 (nominal case) Plan: December 2000 Revised: June 2002	Contractor Award of CRV development contract (Pending broader space transportation decisions within two years).

ACCOMPLISHMENTS AND PLANS

FY 1999

X-38 accomplishments are reported under Payload and Operations/Advanced Projects for FY 1999.

FY 2000 Plans

The X-38 program has been integrated into the Space station budget as part of the CRV program, as the transition from X-38 research and development to CRV design and development begins. Since the scope of the X-38 project objectives were significantly expanded to include early development of technologies directly usable on an operational CRV, the X-38 project will be merged into the CRV project as a part of the ISS Program. X-38 funding and milestones such as completion of CRV operational technology developments and the Vehicle 201 space flight test will continue to be tracked as an X-38 element of the CRV project, but will be accomplished in direct support of, and will be funded by, the CRV project. The CRV Request for Proposals (RFP) for CRV Phase 1 was issued with proposals due by February 20, 2000. The CRV Phase 1 contract will be awarded in the 4th quarter of FY 2000 and work will be initiated in that quarter of the fiscal year. The Memorandum of Understanding (MOU) between the European Space Agency (ESA) and NASA on CRV participation will be complete during FY 2000.

FY 2001 Plans

For FY 2001, the following provides an indication of the design and development work that will be conducted, using both civil servants and contractors.

CRV Vehicle Subsystems

NASA Tasks

Avionics work would include continued development of the CRV inertial guidance system (SIGI Space Integrated GPS/INS); 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 continue.

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.