HUMAN SPACE FLIGHT
FISCAL YEAR 1998 ESTIMATES
BUDGET SUMMARY

OFFICE OF SPACE FLIGHT
SPACE STATION

SUMMARY OF RESOURCES REQUIREMENTS

Space Station	FY 1996	FY 1997	FY 1998
Development	1,746,200	1,766,300	1,386,100
Operations	120,000	177,600	490,100
Research	277,400	204,700	245,100
Total	2,143,600	2,148,600	2,121,300

Distribution of Program Amount by Installation	FY 1996	FY 1997	FY 1998
Johnson Space Center	1,871,429	1,927,300	1,806,200
Kennedy Space Center	50,049	71,000	91,600
Marshall Space Flight Center	118,484	92,800	151,200
Ames Research Center	26,296	19,900	27,300
Langley Research Center	4,867	9,000	4,400
Lewis Research Center	44,136	18,100	26,600
Goddard Space Flight Center	765	100	--
Jet Propulsion Laboratory	2,400	200	2,800
Headquarters	25,174	10,200	11,200
Total	2,143,600	2,148,600	2,121,300

PROGRAM GOALS

The goal of the International Space Station is to provide a long-duration laboratory to allow investigation of the limits of human performance, vastly expand human experience in living and working in space, and provide the capability to understand whether there are additional opportunities for the large-scale commercial development of space. The experience and dramatic results obtained from the use of the International Space Station, together with information obtained from robotic missions to the Moon, near-Earth asteroids, and Mars, will guide the future direction of the Human Exploration and Development of Space Enterprise, one of NASA's key strategic areas. The Space Station is key to NASA's ability to fulfill its mission to explore, use, and enable the development of space for human enterprise.

STRATEGY FOR ACHIEVING GOALS

The Space Station is unique because it will provide the world with a permanent international outpost in space. The schedule for the current design emphasizes an early permanent crew capability that provides an advanced research laboratory for use by international crews for extended durations. Therefore, early into the program, the Space Station will provide the capability to stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge.

The International Space Station (ISS) is the culmination of the redesign work begun in FY 1993 to increase efficiency and effectiveness in response to lower projections for the Agency budget and growing emphasis on other programs. Human presence in space is one of NASA's highest priorities, and the redesigned Space Station has met the President's goal to reduce program costs while still providing significant research capabilities. A new management approach was implemented, in which a single contractor (Boeing) was given total prime and integration responsibilities, with the previous prime contractors (McDonnell Douglas, Rocketdyne, and Boeing Huntsville) serving as first-tier subcontractors to Boeing. This produced clearer lines of authority and greater accountability. In addition, program management relocated to a Space Station Program Office (SSPO) in Houston, structured around integrated product teams with responsibility for bringing the systems and elements into integrated launch packages.

The Space Station program operates within an annual funding constraint of $2.1 billion, with a total budget cap of $17.4 billion at Assembly Complete in June 2002. The baseline program content includes development and operations, Space Shuttle-Mir activities, science payload facilities, and utilization related to the Space Station. Extensive coordination with the user community is ongoing, with payload facilities development and research and technology activities coordinated with the Office of Life and Microgravity Sciences and Applications (OLMSA), and the Office of Mission to Planet Earth (OMTPE).

This past year NASA consolidated the management of Space Station research and technology, science utilization, and payload development with the Space Station development and operations program in order to enhance the integrated management of the total content of the annual $2.1 billion budget. The Space Station program manager is now responsible for the cost, schedule and technical performance of the total program. The OLMSA and OMTPE remain responsible for establishing the research requirements to be accommodated on the Space Station and will respond to the direction of the program manager to ensure the utilization priorities and requirements are consistent with the overall Space Station objectives. The FY 1998 budget reflects that consolidation by funding the total annual $2.1 billion budget within the Space Station budget line of the Human Space Flight appropriation account. The research and technology elements of the program, including Mir research and support, and the station-related space product development activities from the former Office of Space Access and Technology, are included in the Space Station Research funding.

The FY 1998 budget also proposes appropriation language to support multi-year funding to help enable the program to be completed as promised, within budget, and on schedule. The budget proposes $2.1 billion for FY 1998 $2.1 billion for FY 1999, $1.9 billion for FY 2000, $1.6 billion for FY 2001 and $1.1 billion for the first 9 months of FY 2002 in order to achieve completion of U.S. assembly in June 2002.

The Space Station's international aspect was initiated in 1984 with invitations for the full participation of other nations. President Clinton expanded the international scope of the Space Station dramatically by forming a cooperation with the Russian Space Agency (RSA). Space Station team members now include NASA, RSA, the Canadian Space Agency (CSA), the European Space Agency (ESA), and the National Space Development Agency of Japan (NASDA). The continued partnerships with the CSA, ESA, and NASDA significantly enhance the capabilities of the International Space Station, and ensure compatible development of interfacing elements. Through FY 1996, the CSA, ESA and NASDA have invested nearly $6 billion for design and development, and anticipate a total expenditure of $10 billion. In accordance with the terms of the agreements, the U.S. and our international partners will share the total available resources and the common costs for operations. The International Space Station represents an unprecedented level of international cooperation and complexity.

Development of the Space Station program is laid out in three phases. Phase I, which is currently underway, includes nine Shuttle-Mir docking missions. The goals of the Phase I are to develop and demonstrate joint mission procedures with Russia, to gain valuable experience to reduce technical risk during International Space Station construction, and to provide early opportunities for extended scientific research.

Phase II begins with the launch of the U.S.-owned/Russian-launched functional cargo block (FGB) in November 1997. Permanent crew capability for three persons will be available upon delivery of the Soyuz in May 1998. Microgravity capability will be available in January 1999, with the outfitting of the U.S. laboratory. At this stage, the Station configuration will include the U.S. node, laboratory, pressurized mating adapters, power, airlock and mini-pressurized logistics module (MPLM); Russian FGB, docking compartment and crew return; and the Space Station remote manipulator system (SSRMS), provided by Canada.

Phase III will begin in June 1999. Integration of the international modules, including the Japanese Experimental Module (JEM), European Columbus Orbital Facility (COF), Russian research modules, plus the U.S. habitation module in April 2002 will complete the pressurized volume space and crew accommodations. Delivery of the crew rescue vehicle and the final outfitting flight will mark assembly complete of the International Space Station, and permanent 7-member crew capability. At the completion of this phase, the configuration will include a second U.S. node, habitation module, cupola, truss elements and solar arrays; international laboratory and research modules, docking and life support modules, solar arrays and resupply/support vehicles. The centrifuge and the European COF will be launched after permanent 7-member crew capability is achieved.

SPACE STATION DEVELOPMENT

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
Flight hardware	1,468,900	1,480,500	1,157,900
Test, manufacturing and assembly	73,500	97,300	93,600
Operations capability and construction	112,600	130,700	85,400
Transportation support	63,500	55,700	47,800
Flight technology demonstrations	12,900	2,100	1,400
Subtotal	1,731,400	1,766,300	1,386,100
Operations capability and construction Neutral buoyancy laboratory - CofF	14,800	--	--
Total	1,746,200	1,766,300	1,386,100

PROGRAM GOALS

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

STRATEGY FOR ACHIEVING GOALS

Space Station elements will be provided by the U.S. and our international partners. The U.S.

elements include two nodes, a laboratory module, truss segments, four photovoltaic arrays, a habitation module, three pressurized mating adapters, 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. elements also include the FGB energy tug, being provided by a Russian firm under the Boeing prime contract, and pressurized logistics modules, similarly provided by Italy.

Canada, European nations, Japan, and Russia are also developing hardware for the International Space Station. Laboratory elements will be provided by the Japanese and European Space Agencies. Canada will provide the remote manipulator system, vital for assembly of the station. The Russian Space Agency is providing experiment, power, life support and service modules, Soyuz crew transfer vehicle, and universal docking modules.

Boeing is the prime contractor for the Space Station, with responsibility for integration and assembly of the International Space Station. As a subcontra ctor to Boeing, McDonnell Douglas is developing and building the integrated truss segments that separate station elements and house essential systems, including central power distribution, thermal distribution and attitude control equipment. Radiators, communications antennas, photovoltaic (PV) elements and the Space Station robotics manipulator system are also mounted to truss segments. Additionally, McDonnell Douglas provides major components of the communications and data handling, thermal control, and the guidance, navigation and control subsystems.

U.S. pressurized volumes are being developed by Boeing Defense and Space Group, Missiles and Space Division in Huntsville, which is considered a first tier subcontractor to Boeing prime. After the first element launch of the FGB energy block in November 1997, the next flight will launch node 1, a pressurized volume which contains four radial and two axial berthing ports. The node will be launched with two pressurized mating adapters (PMAs) attached and will serve as the docking location for the delivery of the U.S. laboratory module and the pressurized logistics module. Node 2, with an attached cupola, is currently manifested for flight during March 2000. The final U.S. pressurized volume is the habitation module which will contain the galley, wardroom, waste management, water processing and other crew support functions necessary for human operations.

The power system, essential to the Station's housekeeping operations and scientific payloads, is being built by Rocketdyne Division, Rockwell International, in a subcontracted effort to Boeing. Four photovoltaic elements, containing a mast, rotary joint, radiator, arrays and associated power storage and conditioning elements make up the power system.

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

Operations capability provides for the development of a set of facilities, systems and capabilities to conduct the operations of the Space Station. The work will be performed at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC). The KSC will develop launch site operations capabilities for conducting pre-launch and post-landing ground operations. The JSC will develop space systems operation capabilities for conducting training and on-orbit operations control of the Space Station. Construction of the neutral buoyancy laboratory (NBL) in Houston will provide the capability for Space Station crew training to support a March 1997 training need date. Requirements for simultaneous extravehicular activity (EVA) training (up to nine crews at a time) and larger volume for time critical EVA tasks has dictated the NBL requirement.

The redesigned Space Station emphasizes multicenter and multiprogram cooperation. At JSC, a consolidated approach between Space Shuttle and Space Station minimizes duplicated effort and costs for command and control and training. Crew training will be based on a detailed risk analysis to determine the optimum failure response training profile. Therefore, training will be knowledge- and proficiency-based rather than driven by timeline and detailed procedures rehearsal.

Transportation support provides those activities which are required to mate and integrate the Space Shuttle and Space Station systems. This budget line supports development and procurement of two external airlocks, and upgrade of a third airlock to full system capability, which are required both for docking the Space Shuttle with the Russian Mir and for use with the Space Station. Other items in this budget include: the remote manipulator system (RMS) and Space Shuttle mission training facility upgrades; development of a UHF communications system and a laser sensor; procurement of an operational space vision system; procurement of three docking mechanisms and Space Station docking rings; EVA/extravehicular mobility units (EMU) services and hardware; and integration costs to provide analyses and model development.

Space Station technology and system validation funding requirements include flight technology demonstrations, flown during Phase I, in areas of joint NASA/RSA development that pose a level of technical or programmatic risk warranting additional verification. Risk areas include life support, the data processing system, automatic rendezvous and docking, vibration isolation in a microgravity environment, assembly and maintenance, loads and dynamics, contamination, radiation environment, and micrometeoroid/orbital debris. In addition, funding is provided for operational techniques development for procedures, utilizing the Space Shuttle flights to the current Russian Mir, that will benefit the future operational phases of the Space Station program. A change in the logistics requirements for Mir caused a flight cancellation of the solar dynamic technology demonstration payload that was being developed jointly with RSA, and which was co-funded with the Office of Space Access and Technology.

MEASURES OF PERFORMANCE

Performance Milestone	Plan	Actual/Revised	Description/Status
Completed Incremental Design Review	--	--	A series of incremental, cumulative reviews throughout the design phase to assure that system level requirements are properly implemented in the design, have traceability, and that hardware and software can be integrated to support staged assembly and operation. IDR #1 performed these functions for flights 1A through 6A. Subsequently, IDR#2 was conducted during March 1996 to assess design progress for flights 1A through 7A. IDR#2B (September 1996) assessed the entire Space Station assembly sequence.
Perform IDR #2	March 1996	--	IDRs have been replaced by a more classical CDR approach on a stage-by-stage basis, which review groupings of flights with assembly hardware and functionality/performance linkages across the stage.
Perform IDR #3	March 1997	--	Perform Stage Integration Reviews for flights through UF1, FY 1997 Perform Stage Integration Review for flights through 5R, FY 1998

Prime Development Activity -- NOTE: All activities listed are planning milestones, and are not contractual.

Performance Metric	Description/Status

<table>
<tr><td>Flight 1A/R: (November 1997)

FGB Energy Block
(First Element Launch)
(Proton Launch Vehicle)</td><td>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 solar array compartment test on test article (2nd Qtr FY 1996)
Completed manufacture of structural components for first FGB flight (3rd Qtr FY 1996)
Completed subcontractor component deliveries to RSA for FGB assembly (3rd Qtr FY 1996)
Completed manufacture of compartment that houses solar arrays on FGB (2nd Qtr FY 1996)
Completed manufacture of the second of two solar panels for the FGB (3rd Qtr FY 1996)
Complete flight software (slip from 1st Qtr FY 1997 to 3rd Qtr FY 1997)
Deliver FGB flight article to Baikanour (3rd Qtr FY 1997)
Complete factory ground testing of first flight unit (3rd Qtr FY 1997)
Install solar arrays in FGB flight article (1st Qtr FY 1998)
Mating of FGB to Launch Vehicle (1st Qtr FY 1998)
Launch (1st Qtr FY 1998)
On-Orbit checkout, Service Module docking, fuel transfer (1st Qtr FY 1998)</td></tr>
<tr><td>Flight 2A: (December 1997)

Node 1, Pressurized Mating Adapters (PMA-1, PMA-2)</td><td>Initial U.S. pressurized element, launched with PMA-1, PMA-2, and 1 stowage rack; PMA-1 provides the interfaces between U.S. and Russian elements; PMA-2 provides a Space Shuttle docking location.
Completed mechanical equipment installation into node structural test article (STA) (2nd Qtr FY 1996)
Complete Node STA proof pressure/leak rate qualification testing (slip from 4th Qtr FY 1996 to 1st Qtr FY 1997
Begin Engineering, fabrication, assembly, set-up</td></tr>
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and preparation for node STA modal survey test (Slip from 3rd Qtr FY 1996 to 1st Qtr FY 1997)

- Complete installation of mechanical equipment into Node 1 flight article primary structure (Slip from 3rd Qtr FY 1996 to 1st Qtr FY 1997)
- Complete design and fabrication of Node 1 flight article external secondary structure (Slip from 3rd Qtr FY 1996 to 2nd Qtr FY 1997)
- Begin final assembly and outfitting of all major components of Node 1 flight article (Slip from 4th Qtr FY 1996 to 1st Qtr FY 1997)
- Complete pressurized mating adapter (PMA-1) shell (1st Qtr FY 1997)
- Completed mechanical equipment installation into node structural test article (STA) (2nd Qtr FY 1996)
- Complete Node STA proof pressure/leak rate qualification testing (slip from 4th Qtr FY 1996 to 1st Qtr FY 1997
- Begin Engineering, fabrication, assembly, set-up and preparation for node STA modal survey test (Slip from 3rd Qtr FY 1996 to 1st Qtr FY 1997)
- Complete installation of mechanical equipment into Node 1 flight article primary structure (Slip from 3rd Qtr FY 1996 to 1st Qtr FY 1997)
- Complete design and fabrication of Node 1 flight article external secondary structure (Slip from 3rd Qtr FY 1996 to 2nd Qtr FY 1997)
- Begin final assembly and outfitting of all major components of Node 1 flight article (Slip from 4th Qtr FY 1996 to 1st Qtr FY 1997)
- Complete pressurized mating adapter (PMA-1) shell (1st Qtr FY 1997)
- Complete STS-88 Cargo Integration Review (1st Qtr FY 1997)
- Complete PMA-2 shell (Slip from 4th Qtr FY 1996 to 2nd Qtr FY 1997)
- Begin PMA-1 & 2 acceptance test (2nd Qtr FY 1997)
- Stage Integration Review #1 (2nd Qtr FY 1997)
- PMA 1 & 2 on dock at KSC (3rd Qtr FY 1997)
- Complete Node 1 acceptance test (3rd Qtr FY

	1997) ● Node 1 on dock at KSC (3rd Qtr FY 1997) ● Complete Node STA static flight loads testing (4th Qtr FY 1997) ● Complete Flight 2A Cargo Element Integration and Test (1st Qtr FY 1998) ● Space Shuttle Payload Integration and Test (1st Qtr FY 1998) ● STS-88 Launch (1st Qtr FY 1998)

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<td>Flight 3A: (July 1998)

Z1 Truss Segment, Control Moment Gyros (CMGs), PMA-3, KU-Band</td>
<td>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.

Began Z1 truss Critical Design Review (2nd Qtr FY 1996)
Began fabrication and assembly of Z1 truss (2nd Qtr FY 1996)
Completed design of CMGs (1st Qtr FY 1996)
Began build of CMG flight articles 1-4 (2nd Qtr FY 1996)
PMA-3 pressurized shell & secondary structure on-dock at McDonnell Douglas for tooling & fabrication (2nd Qtr FY 1996)
Begin fabrication of 3A Flight Model DDCUs (1st Qtr FY 1997)
Complete fabrication and assembly of CMG qualification unit (Slip from 3rd Qtr FY 1996 to 2nd Qtr FY 1997)
Z1 fabrication and assembly complete (2nd Qtr FY 1997)
Complete flight article CMG acceptance test for flight unit #1 (2nd Qtr FY 1997)
Complete Z1 Truss Critical Design Review (2nd Qtr FY 1997)
Z1 modal and static qualification tests complete (4th Qtr FY 1997)
PMA-3 on-dock at KSC (Slip from 3rd Qtr FY 1997 to 4th Qtr FY 1997)
KU-Band on dock at KSC (2nd Qtr FY 1998)
S-Band on dock at KSC (2nd Qtr FY 1998)

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<td>Flight 4A: (November 1998)

P6 Truss segment, Photovoltaic Array, Thermal Control System (TCS) Radiators, S-Band Equipment</td>
<td>Establishes initial U.S. photovoltaic module based power capability; installed in a temporary location on top of the Z1 truss until flight 13A when it is permanently attached to the P5 truss; includes 2 TCS radiators for early active thermal control.

Completed P6 long spacer qualification unit design

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	(2nd Qtr FY 1996) ● Completed Flight PVR final assembly and began acceptance testing (4th Qtr FY 1996) ● Completed EEATCS delta CDR (4th Qtr FY 1996) ● Complete mechanical installation and outfitting of IEA qualification unit (Slip from 4th Qtr FY 1996 to 1st Qtr FY 1997) ● Complete deploy and retraction testing on PV arrays pre-flight qual Unit (1st Qtr FY 1997) ● Complete E-wing life cycle testing (1st Qtr FY 1997) ● Complete assembly of P6 integrated electronics assembly (IEA) qualification unit (1st Qtr FY 1997) ● Complete IEA qualification unit hardware/software integration and functional testing (1st Qtr FY 1997) ● Begin thermal balance testing of IEA qualification unit (2nd Qtr FY 1997) ● Begin P-6 long spacer flight hardware fabrication/assembly (1st Qtr FY 1997) ● Complete fabrication and assembly of P6 long spacer qualification unit (3rd Qtr FY 1997) ● Complete IEA flight unit fabrication (3rd Qtr FY 1997) ● P6 long spacer on dock at KSC (2nd Qtr FY 1998) ● IEA to KSC (2nd Qtr FY 1998) ● Complete flight qualification IEA testing (3rd Qtr FY 1998) ● PV Arrays flight units on dock at KSC (3rd Qtr FY 1998)

Flight 5A: (December 1998) U.S. Laboratory, 5 Lab System Racks	Establishes initial U.S. user capability; launches with 4 system racks preintegrated; KU-band and CMGs are activated. ● Begin laboratory common module STA qualification testing (Slip from 4th Qtr FY 1996 to 1st Qtr FY 1997) ● Complete development of lab flight article pressure vessel (Slip from 4th Qtr FY 1996 to 2nd Qtr FY 1997) ● Standoff endcones - Design completed (Slip from 4th Qtr FY 1996 to 2nd Qtr FY 1997) ● Complete Mission Integration Plan Baseline (2nd Qtr FY 1997) ● Complete Flight 5A Stage Integration Review (4th Qtr FY 1997) ● Complete lab racks, crew systems, closeouts, and hatch installation (1st Qtr FY 1998) ● Complete Cargo Integration Review (1st Qtr FY 1998) ● Complete Lab qualification testing (hardware/software integration) (3rd Qtr FY 1998) ● Lab on dock at KSC (4th Qtr FY 1998)

Flight 6A: (January 1999) Mini-Pressurized Logistics Module, Canadian Remote Manipulator System, UHF	Adds U.S. lab outfitting with 1 stowage and 7 systems racks; UHF antenna provides space-to-space communication capability for U.S. based EVA; manifests Canadian SSRMS needed to perform assembly operations on later flights. ● Completed fabrication of MPLM-1 qualification unit (3rd Qtr FY 1996) ● Begin fabrication and assembly of MPLM-1 flight article (3rd Qtr FY 1996) ● Deliver SSRMS Structural Test Article to NASA (2nd Qtr FY 1997) ● Baseline Flight 6A Mission Integration Plan (2nd Qtr FY 1997) ● Complete MPLP System Critical Design Review (2nd Qtr FY 1997) ● Complete MPLM FM1 structure manufacturing and assembly (3rd Qtr FY 1997) ● Complete Stage Assessment Review (4th Qtr FY 1997) ● Complete Stage Assessment Integration Review (4th Qtr FY 1997) ● Cargo Integration Review (2nd Qtr FY 1998) ● Begin integration of Spacelab Logistics Pallet Cargo Element (2nd Qtr FY 1998) ● Deliver MPLM to KSC (3rd Qtr FY 1998) ● Deliver Lab Racks to KSC (4th Qtr FY 1998) ● Complete Flight Operations Review (4th Qtr FY 1998)
Non-Prime Development Activity	
Global Positioning System	Provides autonomous, real-time determination of Space Station's position, velocity, and attitude of absolute time ● Complete Critical Design Review (4th Qtr FY 1996) ● Deliver GPS Receiver/Processor (3rd Qtr FY 1997) ● Deliver GPS Antenna Assembly (2nd Qtr FY 1998)

Extra-Vehicular Activity System	• Provides GFE EVA unique tools, Orlan SAFER (Russian space suit), and EVA support equipment for the Space Station. Provides EVA development and verification testing. Provides for operation of the WETF/NBL and the maintenance of neutral buoyancy mockups to support Station EVA development activities. • Deliver Crew Equipment Transfer Aid Cart Proto-Flight unit (1st Qtr FY 1997) • Deliver Bi-Lateral Tools for Testing (2nd Qtr FY 1997) • Deliver Articulating Portable Foot Restraints (3rd Qtr FY 1997) • Deliver Orbital Support Equipment (3rd Qtr FY 1997) • Deliver Torque Multiplier (3rd Qtr FY 1997) • Deliver Orlan SAFER - first 2 units (1st Qtr FY 1998) Deliver Temporary Equipment Restraint Aid (2nd Qtr FY 1998)
Crew Health Care System	• Provides crew health care system hardware included in the health maintenance system, and the countermeasure system required to ensure crew health and safety. This activity and measures of performance have been transferred to Space Station Research.

Flight Crew Systems	Provides flight and training hardware and provisions for food and food packaging development; housekeeping management; portable breathing apparatus; restraints and mobility aids, tools and diagnostic equipment and portable illumination kit. • Complete Critical Design Review (tools/diagnostics/housekeeping (4th Qtr FY 1996) • Complete 6A Operations and Personal Equipment CDR (1st Qtr FY 1997) • Complete Stowage Tray Restraint CDR (2nd Qtr FY 1997) • Complete production of tools and diagnostic flight hardware kit (1st Qtr FY 1998) • Complete CDR for portable illumination (1st Qtr FY 1998) • Complete Personal Hygiene Kit PRR (3rd Qtr FY 1998) • Deliver Maintenance Workstation Kit, Tools and Diagnostic Kit, Portable Illumination, Restraints and Mobility Aids, 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. • Completed Critical Design Review (4th Qtr FY 1996) • Certification unit hardware delivered to Airlock Test Article (Slip from 2nd Qtr FY 1996 to 2nd Qtr FY 1997) • Complete certification unit integration test (4th Qtr FY 1997) Complete flight unit acceptance test (4th Qtr FY 1997)

Station Training Facility	Primary facility for space systems operations training and procedures verification. ● Part task trainer ready for Flight 1A (4th Qtr FY 1996) ● Achieved Mission Control Center (MCC)/STF integrated operations capability (3rd Qtr FY 1996) ● Training capability to support flight 2A (3rd Qtr FY 1997) Ready For Training (RFT) for flight 5A (4th Qtr FY 1998)
Integrated Planning System	Provides planning and analysis tools for pre-increment and real-time operations systems (IPS) supporting trajectory/flight design, timelines, resource utilization, onboard systems, performance analyses systems operation data file procedures and control, maintenance operations, inventory and logistics planning, robotics analysis, procedures development. ● Achieved first element launch capability (2nd Qtr FY 1996) ● Delivery to support Flight 5A planning and operations (3rd Qtr FY 1997) ● Delivery to support Flight 1J/A (2nd Qtr FY 1998)
Mission Control Center	Facility providing integrated command and control capabilities and support to real-time increment operations. ● Achieved capability for: ascent/entry; full Mir command/telemetry support; data record/playback; initial voice record/playback (3rd Qtr FY 1996) ● SVF integration test for flights 2A-4A (2nd Qtr FY 1997) ● Delivery to support Flight 2A flight following capability (3rd Qtr FY 1997) ● Delivery to support CSA Interface and Payload Interface (3rd Qtr FY 1998) ● Delivery to support Flight 5A ISS Command and Control Capability (4th Qtr FY 1998)

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

ACCOMPLISHMENTS AND PLANS

FY 1996 continued qualification testing, and the manufacturing of flight hardware as the program readies for First Element Launch (FEL) in November of 1997. The Incremental Design Review (IDR) #2A (March 1996) performed a Critical Design Review (CDR) for flights 1A through 7A. IDR #2B (September 1996) assessed the entire assembly sequence. International efforts continued with closure of the NASA/RSA Memorandum of Understanding (MOU) on Space Station and renegotiation of MOUs with ESA, Japan, and Canada to reflect Russian participation. The ESA Ministerial Council met to finalize ESA participation in Station and all partners continue development of flight hardware. The Columbus orbital facility (COF) will reach PDR, the Japanese experimental module (JEM) will undergo CDR #1 and the Space Station remote manipulator system (SSRMS) will finish final integration.

Power system testing was conducted throughout FY 1996, including the battery charge/discharge unit (BCDU), Type II remote power connectors (RPC), main bus switching unit (MBSU), direct current switching unit (DCSU), external and internal DC-to-DC converter units, and the pump and flow control subassembly (PFCS). The integrated electronics assembly (IEA) qualification unit hardware/software integration and functional testing was completed (1st Qtr FY 1997).

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

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

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

Integration of node 1 and PMA 1 and 2 will occur during FY 1997. The Z1 truss fabrication and assembly, CMG flight article fabrication and the Integrated Electronics Assembly (IEA) structural framework fabrication are to be completed before the end of fiscal year 1997. The Mini-Pressurized Logistics Module (MPLM) will undergo CDR and the primary structure will be manufactured and assembled. Installation of lab endcone hardware, racks and hatches will begin.

FY 1998 will see Phase 2/3 assembly of the International Space Station begin with the launch of the U.S. owned/Russian launched Functional Cargo Block (FGB). The FGB is a self sufficient orbital vehicle that will provide initial capabilities for propulsion, guidance, communication, electrical power and thermal control systems.

Launch of Node #1 (1 stowage rack), PMA 1 & PMA 2 by the Space Shuttle will follow. PMA 1 will provide a pressurized tunnel between the U.S. pressurized elements and the Russian Modules. The PMA 2 will provide a Shuttle docking location.

On flight 1R, the Russian-provided Service Module will contain all the systems necessary for independent orbital operations and serves as a habitat and laboratory. The Service Module launch schedule is under review and contingency options are being addressed. Flight 2R launches a Soyuz crew transfer vehicle giving the International Space Station three person human permanent presence capability, and initial science research microgravity capability will follow.

Flight 3A launches the first truss segment Z1, the third PMA, Ku-band, control moment gyros, S-Band equipment, and Extravehicular Activity Subsystem (EVAS) components. The Z1 truss segment serves as a temporary location for the first Photovoltaic (PV) assembly (P6).

SPACE STATION OPERATIONS

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
Vehicle operations	37,500	58,500	277,500
Ground and transportation operations	82,500	119,100	212,600
Total	120,000	177,600	490,100

PROGRAM GOALS

The first objective of the operations program is to provide for the safe, reliable, and sustained operation of the Space Station and the ground and transportation operations required to plan, train, and fly the vehicle. The second major goal is to perform the operations in a simplified and affordable manner. Space Station operations will rely on the infrastructure developed for the Space Shuttle, and the experience derived from the Space Shuttle-Mir program to develop efficient and effective operations. Finally, operations will facilitate the transition of the various elements of development to the operations program.

STRATEGY FOR ACHIEVING GOALS

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

Vehicle operations will provide post-development systems engineering and integration to sustain the specification performance and reliability of Space Station systems, logistics support for flight hardware and launch site ground supportequipment, configuration management, and any associated procurement activity.

Vehicle operations sustaining engineering will be performed by a small cadre of civil service system experts supported by a small number of sustaining engineering contractors. Additionally, flight hardware and software sustaining engineering will be consolidated at the Johnson Space Center (JSC) to allow all flight hardware and software to be handled under a single contract.

Maintenance and repair costs continue to be minimized by the application of logistics support analysis to the design, resupply/return and spares procurement processes. Flight hardware

Ground operations will provide command and control, training, operations support and launch site processing. A unified command and control center for the Space Station is composed of the Mission Control Center-Houston (MCC-H) and the Mission Control Center-Moscow (MCC-M) at Kaliningrad. The MCC-H will be the prime site for the planning and execution of integrated system operations of the Space Station. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite System (TDRSS) system and the Russian communication assets.

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

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

Cargo integration support will provide 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.

MEASURES OF PERFORMANCE

Performance Metric	Plan	Actual/Current	Description/Status
Baseline first multi-increment manifest	Plan: January 1996	Actual: November 1996	Multi-increment Manifest delayed due to assembly sequence rebaselining
Baseline sustaining engineering implementation	Plan: June 1996	Actual: September 1996	Details the roles and responsibilities of NASA and the prime contractor for sustaining the International Space Stationhardware and software after delivery to NASA.
Demonstrate MCC-H to MCC-M telemetry support capability	Plan: July 1996	Actual: April 1996	Development of the Mission Control Center - Houston (MCC-H) to Mission Control Center-Moscow (MCC-M) (demonstrated as part of Phase I flight following activity) telemetry capability necessary for the support of the Space Station flight vehicle.
Baseline International Space Station program implementation plan	Plan: December 1996	Actual: October 1996	Details the roles, responsibilities, and implementation plans for NASA and its international partners to support International Space Station operations.
Publish Preliminary Flight Rules	Plan: January 1997	--	ISS Generic Flight Rules, Volume B Development of ISS Flight Rules continues with participation by International Partners and Shuttle.
Baseline Second Multi-Manifest	Plan: April 1997	--	Annual update of multi-increment manifest covering Program multi-lateral vehicle traffic and crew rotation plan through Assembly Complete.
KSC ground support equipment ready to support Flight 2A	Plan: April 1997	--	Completion of the design, manufacture, and activation/validation of KSC supplied ground support equipment for Flight 2A will provide a basic processing capability to support all Station hardware flights.

Baseline mission integration plan for UF-1	Plan: May 1997	--	Required to define utilization flight (UF-1) mission requirements and payloads.
Complete MCC-H/SSTF integrated operations training capability	Plan: May 1997	--	Supports the training schedule to train ground crews for real-time operations of the Space Station vehicles.
Complete SSPF operational readiness	Plan: June 1997	--	Completion of the installation and activation of the Space Station Processing Facility (SSPF) and facility systems. Provides the capability to support launch site processing of the KSC launched cargo elements.
Demonstrate MCC-H to MCC-M Command Support Capability	Plan: August 1997	--	Development of the Mission Control Center - Houston (MCC-H) to Mission Control Center - Moscow (MCC-M) command capability re-essay for the support of Space Station Operations.
Begin MCC-H ISS flight follow-ing with flight 1 A/R and 2A	Plan: November 1997	--	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.
Publish MIM 98-1	Plan: April 1998	--	Annual update of the multi-increment manifest (MIM) covering Program multi-lateral vehicle traffic and crew rotation plan through assembly complete.
Publish Operations Summary 98	Plan: June 1998	--	Annual update to the ISSP Operations Summary, which defines basic ISS resources available for long range utilization planning.
Baseline IDRD PP#3	Plan: July 1998	--	The IDRD includes requirements and resource allocations for Planning Period 3 which covers the 2000 timeframe.

ACCOMPLISHMENTS AND PLANS

In FY 1996, funding supported MCC-M command and telemetry capability development and data/voice record and playback capability. The integrated planning system has initial Station capability to support planning for first element launch. Supply, transportation, and site facilities support infrastructure required for spares and repairs was provided in preparation for major buys that will begin in FY 1997. Additionally, long lead spare items such as electrical, electronic, and electro-mechanical (EEE) parts were purchased to support orbital replaceable unit (ORU) spares. Also in FY 1996, the International Space Station program planning established integrated traffic and crew rotation plans for Phase 2 through the development of the multi-increment manifest. Program operational requirements were established through increment definition and requirements documentation (IDRD). Flight products were developed in draft form as part of the normal two-year flight production template flight rules and procedures.

In FY 1997, work will continue on KSC launch site requirements definition, processing plans, and scheduling, as well as the development of ground support equipment and the test control and monitor system (TCMS). The SSPF and facility systems installation, activation, and validation will continue until the operational readiness date, which is set for June 1997. A change will be made to the ISS Prime Contract to add Sustaining Engineering effort through Assembly Complete plus 12 months. Final preparations for the first element launch will be reviewed through the increment integration review for Increment 1. Plans for the first utilization flight will be formally defined through approval of the Shuttle mission integration plan for UF-1. The SSTF and MCC-H will be ready to begin crew and ground controller training for flights 1A-4A. Also during FY 1997, the integrated planning system will be ready to support planning for the 1A-5A flights. The basic mission rules and operations data file for flights 1A-4A will also be produced. In FY 1997 and FY 1998, suppliers and original manufacturers will be put on repair retention contracts to ensure repair of failed equipment and continued operation of ISS. Procurement of spares below the equipment level will be a major thrust in FY 1997.

In FY 1998, the MCC-H will begin functioning in a flight-following mode of operation starting with the first element launch on ISS flight 1A/R, and will continue to operate in this mode throughout FY 1998. The MCC-H is planned to take over the primary real-time command and control of the ISS in early 1999. Updates to the multi-increment manifest and to the definition of ISS resources available for long range utilization planning will continue, and the IDRD for the year 2000 timeframe will be baselined.

SPACE STATION RESEARCH

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
Mir research and support	81,700	58,200	45,300
Utilization support	47,400	35,100	62,300
Research facilities	128,500	80,400	102,500
Science utilization	16,500	31,000	35,000
Subtotal	274,100	204,700	245,100
Science utilization Addition to Microgravity Development Laboratory - CofF	3,300	--	--
Total	277,400	204,700	245,100

PROGRAM GOALS

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

As NASA moves into the Space Station era, there will be a major transition from the current on-orbit experimentation program to the ISS. The core of the Space Station program will be seven major research facilities: the Gravitational Biology Facility (GBF), the Centrifuge Facility (CF), the Human Research Facility (HRF), the Space Station Furnace Facility (SSFF), the Biotechnology Facility (BTF) (which includes the Protein Crystal Growth activities), Fluids and Combustion Facility (FCF) and the Low Temperature Microgravity Physics Facility (LTMPF). In addition to the seven major facilities, NASA will develop Laboratory Support Equipment and the Expedite the Processing of Experiments to Space Station (EXPRESS) racks and pallets for the Station.

STRATEGY FOR ACHIEVING GOALS

A number of changes to the Space Station research program have occurred over the past year. NASA consolidated the management of Space Station research and technology, science utilization, and payload development with the Space Station development and operations program in order to enhance the integrated management of the total content of the annual $2.1 billion budget. The Space Station program manager is now responsible for the cost, schedule and technical performance of the total program. The OLMSA and OMTPE remain responsible for establishing the research requirements consistent with the overall Space Station objectives. The FY 1998 budget reflects that consolidation by funding the total annual $2.1 billion budget within the Space Station budget line of the Human Space Flight appropriation account. The research and technology elements of the program, including Mir research and support, and the station-related space product development activities from the former Office of Space Access and Technology, are included in the Space Station Research funding.

The program has undergone a major restructuring in order to match research utilization of the on-orbit resources with the research support capabilities during the assembly period, and to enhance science planning and training for long-term operations. Current reviews of research facilities, payloads, and user operations against the NASA research objectives will be completed in early spring of 1997 to ensure that the maximum strategic scientific and technological return is achieved. In order to more closely align the delivery of the research facilities to the Station with the availability of crew time, power and upmass capabilities, as well as to address fiscal constraints, several research facilities are now targeted for delivery toward the end of the assembly phase of the Station. In addition, early research on board the Station during the assembly/construction phase is being realigned to the available resources. Rephasing the overall research resulted in the flexibility to transfer $50 million in FY 1996 and $177 million in FY 1997 from research to Space Station development. The funding levels in FY 1999 - FY 2002 will be planned to provide for the priority major research facilities and the associated research infrastructure to be in place at the conclusion of the assembly phase of the Station. As a consequence of the reviews to date, U.S. funding requirements for the Centrifuge Rotor and the Life Sciences Glovebox have been deleted with the assumption that an international partner will agree to assume the responsibility for developing these components in lieu of exchange for other considerations provided by NASA.

Mir research and support

Mir research and support provides for early research opportunities during Phase 1 by conducting long-duration science aboard the Russian Mir space station, as well as shorter duration science investigations on the Space Shuttle rendezvous missions to Mir. Nine Space Shuttle missions to Mir are planned: four were completed by the end of FY 1996, three are planned for FY 1997, and two in FY 1998. The primary objectives of these flights are to rendezvous and dock with the Mir; perform on-orbit, joint U.S./Russian science and research;

perform on-orbit joint operations, which will serve as a platform for future ISS operations; resupply Mir logistics; and rotate the American astronauts on-board Mir. The first of these flights employed a Spacelab long module to support experiment transport and operation, as well as the transport of Mir hardware. The second flight delivered a docking module and solar arrays to Mir**.** Seven other flights require pressurized habitable modules to transport Russian logistics items, NASA and Russian science and technology payloads, and ISS risk mitigation payloads to Mir. Modules for Flights 3 through 9 are being supplied under a contract with Spacehab, Inc.

The Russian government is making a contribution toward the success of this mission by providing access to their Mir Space Station, providing training for our astronauts, and working with NASA to develop joint operational procedures. By contributing their expertise in long-duration missions gained through many years of Mir operations, and assisting NASA in the development and test of procedures used to rendezvous and dock with the Mir, they are strengthening NASA's ability to assemble safely and efficiently operate and use the ISS. Major contractors involved in the U.S./Russian Cooperative program include the RSA, the RSC-Energia, Krunichev, the Gagarin Cosmonaut Training Center, Rockwell International, Spacehab, Inc., Boeing, Rocketdyne, Allied Signal, and Lockheed Martin.

The Life Science NASA/Mir Research Program (NMRP) will support research investigations in environmental monitoring and countermeasures development and validation aboard the Mir. These investigations will emphasize musculoskeletal, cardiovascular, regulatory physiology, and neuroscience research, along with plant biology and other fundamental biology research. The Biorack facility developed by the European Space Agency (ESA) will fly on three of the Space Shuttle flights to the Mir. The Biorack will be accommodated inside the pressurized Commercial Middeck Accommodations Module (CMAM),owned by SpaceHab, Inc. Biorack researchers will investigate the influence of gravity on cellular functions and developmental processes in plant and animal tissues. NASA will also use Mir to perform flight experiments in environmental control, advanced life support systems, and advanced space station crew health care systems. These investigations will reduce technical, schedule, and cost risks associated with the development and operation of the ISS.

The Microgravity NASA/Mir Research Program (NMRP) seeks to mitigate risk in scientific, technological, logistical, and operational planning for the use of the International Space Station. Additional goals of the NMRP are to characterize the microgravity environment on Mir and to conduct specific United States investigations in microgravity and application research disciplines. The NMRP has utilized modified Space Shuttle experiment apparatus, flight samples, science operations, and data analysis/procedures in order to allow United States investigators to fully maximize the capabilities of the Mir Space Station.

The Space Biomedical Center for Training and Research, a collaboration between NASA and several Russian organizations, including the Russian Space Agency, the Ministry of Science and Technology Policy in Moscow, and the Institute of Biomedical Problems, established at the Moscow State University in 1995, continues to operate. This Center focuses on several activities including aerospace medicine training, medical education, telemedicine, and terrestrial applications of space technology from the Russian Space Program. Medical education is being supported between select US medical centers and MSU using emerging telecommunications and information technologies.

Utilization support

Utilization support provides the necessary capabilities to provide access to the International Space Station (ISS) for payloads by commercial, academic and government researchers. These capabilities provide the facilities and systems 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 expected to maintain the least cost and highest flexibility to both the user community and NASA. User/payload operations are integrated to ensure compatible use of ISS resources and to resolve payload requirement conflicts. Payload operations integration is provided across all United States and International Partner user operations. Once developed, user support services and systems will be maintained and available throughout the life of ISS.

A variety of facilities, services, and systems are provided for user/payload support. Utilization support services provides pre-flight payload checkout support, payload operations integration, payload training, mission planning, and analytical integration. These services are consolidated to eliminate duplication of effort and increase over all efficiency while supporting distributed payload operations by the user community. 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, capability for quick access by the user community, training of ground and flight teams, 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 including activity scheduling during the mission.

For the redesigned ISS, the payload integration process has been streamlined and significantly shortened. Standardized payload accommodations are provided for modularity, flexibility and streamlined manifesting of user payloads. An express rack concept has been adopted to drastically shorten user pre-flight payload preparation activities.

On the ground, the Payload Operations Integration Center (POIC)/United States Operations Center (USOC), Payload Data Services System (PDSS) and the Payload Planning System (PSS) provide the user community with the tools and resources to access ISS flight payload services and conduct operations from their home laboratories. For those users requiring payload facility services, the USOC provides accommodations for payload users to conduct ground based operations. Development cost of these systems has been reduced by utilizing generic architecture which supports multiple programs including Space Shuttle, Spacelab, and the Advanced X-Ray Astrophysics Facility (AXAF).

Supporting pre-flight payload activities, utilization support includes user assistance services, payload checkout systems, and necessary support to prepare experiments for launch and on-orbit operation. Among the systems provided are the Payload Rack Checkout Unit (PRCU), and the Suitcase Test Environment for Payloads (STEP). A Payload Data Library (PDL) is provided to integrate all payload flight data for quick and efficient configuration of flight and ground payload systems.

Integrated services are also provided at the integrated ISS level to ensure full, efficient, and compatible user utilization of ISS resources including the International Partners. This function includes payload integration, training, and payload operations integration services. These services are supported by the POIC systems, and provide the final integration making the ISS a truly international resource.

Research facilities

As one of the primary NASA users of the Space Station, the Life and Microgravity Sciences and Applications program sponsors a robust program to develop flight experiment apparatus, ground-based facilities and operations protocols needed to make the Space Station's unique capabilities available to the United States. The program includes seven facilities and four projects: Human Research Facility (HRF); Gravitational Biology Facility (GBF); Centrifuge Facility (CF); Space Station Furnace Facility (SSFF); Fluids and Combustion Facility (FCF); Biotechnology Facility (BTF) (which includes Protein Crystal Growth activities); Low-Temperature Microgravity Physics Facility (LTMPF); the Risk Mitigation Project, the Expedite the Processing of Experiments to Space Station (EXPRESS) Rack Project, the EXPRESS Pallet Project, and the Laboratory Support Equipment (LSE) project.

The HRF will define and develop space flight research hardware to serve a number of closely related objectives. The HRF hardware suite will enable the standardized, systematic collection of data from the Space Station's crew members, which the medical and research community will require in order to assure crew health. Once verified on-orbit, the HRF will also be used to conduct basic and applied human research and technology experiments.

In addition to the biomedical research that will be conducted using the HRF, NASA's biomedical commitment aboard the ISS will include the suite of hardware necessary to protect crew health. The Crew Health Care Subsystem (CHeCS) being developed by JSC will support medical care requirements for the ISS crew following deployment of the U.S. Laboratory module in late 1998. 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 will be evaluated, with the synergy between the two programs resulting in efficiencies and cost savings.

The combination of the GBF and CF make up a complete on-orbit laboratory for NASAís Biology Research Program. The two facilities will be developed in an integrated manner. The GBF will design, develop, and conduct the on-orbit verification of Space Station research equipment to support the growth and development of a variety of biological specimens, including animal and plant cells and tissues, embryos, fresh and salt water aquatic organisms, insects, higher plants, and rodents. The GBF will support specimen sampling and storage as well as limited analysis activities. The GBF's modular design will accommodate the incremental development of experiment capabilities in a manner consistent with evolving ground and flight science needs of the research community.

The CF includes two habitat holding systems, a two-and-a-half meter diameter centrifuge rotor, life sciences glovebox, and a service system rack. The project will also include a biotelemetry system to support ground-based data analysis of in-flight experiments. The Space Station Program Office is pursuing negotiations with the Japanese to provide the centrifuge rotor, life sciences glovebox and the Centrifuge Accommodation Module in exchange for NASA-provided launch services or other offsets.

The BTF supports protein crystal growth and studies on the maintenance and response of mammalian tissue cultures in a microgravity environment. The facility will provide a support structure as well as integration capabilities for individual biotechnology experiment modules. Its modular design will provide the flexibility to accommodate a wide range of experiments in cell culturing and protein crystallization. The facility will accommodate changes in experimental modules and analytical equipment in response to changes in science priorities or technological advances. The BTF will support a large group (>50) of academic, commercial and government scientists. JSC will develop this facility.

The FCF supports research on interfacial phenomena, colloidal systems, multiphase flow and heat transfer, solid-fluid interface dynamics, and condensed matter physics, and definition of the mechanisms involved in various combustion processes in the absence of strong buoyant flows. The facility core will provide common support systems for both the combustion and the fluids modules. The Fluids Module Experiment Rack will be designed to accommodate several multi-purpose experiment modules that are individually configured with facility-provided and experiment-specific hardware to support each fluids experiment. The Combustion Module will house a combustion chamber that is equipped with ports to allow an array of modular diagnostic systems to view the experiment. LeRC will develop this facility.

The SSFF is used to study underlying principles necessary to predict the relationships of synthesis and processing of materials to their resulting structures and properties. The facility core, which will provide the main interface to the Space Station services, will consist of furnace subsystems common to many types of investigations. The experiment modules will be composed of multi-user or investigator-unique modules that will be designed for high reliability and long life. NASA will be able to reconfigure the modules and will have the capability of on-orbit reconfiguration to support many different types of investigations. It is anticipated that cooperative efforts with the international science community will assist in the development of some discipline-specific furnace modules for use by the U.S. science community, thus leveraging the hardware development investments undertaken by NASA. MSFC will develop this facility.

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. An EXPRESS Rack concept has been adopted to drastically shorten user pre-flight payload preparation activities. The EXPRESS projects will provide an efficient payload integration capability for smaller payloads with a limited amount of resources. The EXPRESS Rack project will develop the racks and pallets necessary to accommodate these smaller payloads, within the pressurized volume as well as external attachments to the Station . The EXPRESS Rack will enable a simple, streamlined analytical and physical integration process for small payloads by providing standard hardware and software interfaces. The project includes a precursor flight of an EXPRESS rack in FY 1997 on the MSL-1 Spacelab mission. EXPRESS racks will be available to support initial payload operations in the U.S. Laboratory on the ISS. The EXPRESS Pallet project provides small attached payloads with a similar streamlined process and hardware and software interfaces. MSFC is responsible for developing the EXPRESS Racks and Pallets.

Currently planned attached payloads include SAGE III, which measures stratospheric properties for ozone depletion research, and the Low Temperature Microgravity Physics Facility which accommodates fundamental physics experiments at very low temperatures in a microgravity environment. Also planned is the Alpha Magnetic Spectrometer, a cooperative project with the Department of Energy, which measures cosmic rays in order to perform fundamental cosmological research.

Laboratory Support Equipment (LSE) is also under definition review for the Space Station in order to support Life and Microgravity Sciences and other experiments. Four pieces of equipment are currently being reviewed. LeRC is reviewing the Film Locker and the electro-magnetic shielded locker. MSFC is reviewing the Video Camera and the Digital Thermometer. Both Centers are currently reviewing requirements and cost estimates for LSE and plan to revise facility development based on more specific requirements definitions. Other LSE items currently under study or in development at ARC include the passive dosimeter, specimen labeling tools, microscopes, small mass measurement device, pH meter, incubator and refrigerated centrifuge.

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 the activities, the commercial research programs for the ISS will concentrate on Commercial Protein Crystal Growth, 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 Integrated Space Station Engineering Center (ISSEC) at JSC is planned to maximize the use of the ISS as a unique on-orbit laboratory and to foster partnerships with other US Government, industrial, and academic communities. The ISS will be used for long duration and reconfigurable development of technology products that validate new concepts for civilian space activities. The ISSEC intends to identify, and define innovative technology concepts beginning in FY 1997, then 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 ISSEC program will promote the fast track implementation of these experiments. At the same time, the ISSEC program intends to obtain proposals for the facilities which can provide the necessary support for one or more experiments to operate without duplication of functions.

The HRF development effort will be managed primarily as an in-house effort at JSC, but it will draw contractor support primarily from Lockheed-Martin and Krug Life Sciences. Lockheed-Martin will provide project engineering and related services in support of HRF hardware development and modification. Krug Life Sciences will support science requirements development and definition at JSC. The GBF and the CF projects will rely upon the international participation described below, as well as selected support contractors. The Lockheed-Martin Corporation will support science definition and development for the GBF and CF. Boeing is developing the Habitat Holding Rack for ARC. This rack is a derivative of the EXPRESS rack and will provide programmatic synergy and cost savings to the program. The BTF project is led by JSC, with contractor support from Krug Life Sciences Corporation. The FCF is led by the LeRC, with contractor support from the NYMA and Analex Corporations. The SSFF effort is led by the MSFC as an in-house effort. Boeing and Lockheedís Palo Alto Research Center are developing cryogenic freezers as part of the LSE Project.

NASA is actively pursuing international participation the Space Station facility projects. For example, the GBF project has contacted the space agencies of Japan and Canada to solicit their participation in the development of an aquatic habitat and insect habitat. A multilateral users working group, consisting of representatives from all the major ISS participating countries, has agreed to principles for eliminating redundant flight hardware. NASA and the European Space Agency (ESA) have established a bilateral agreement to develop three flight copies of a -80o C freezer. NASA and ESA also have a bilateral agreement in principal to develop a

Microgravity Sciences Glovebox whose capabilities are specified by NASA and will be available for use by all international Space Station microgravity researchers. The Centrifuge Accommodation Module (CAM), the Centrifuge Rotor, and the Life Sciences Glovebox are being negotiated with the National Space Development Agency of Japan (NASDA). The Biological Research Program (BRP) is participating with the Hungarian Space Agency to develop passive radiation monitors and an on-board badge reader as part of the LSE Project. NASA will pursue other agreements of this sort in order to increase the science returns and the economies of the ISS program.

Science utilization

Space Station Science Utilization will enable researchers to use the ISS as a unique laboratory for the United States research and technology community. The utilization program will support the development of experiment-unique flight hardware, engineering support to United States Principal Investigators, ground-based facilities, and science operations in the biotechnology, combustion science, fluid physics and transport phenomena, fundamental physics, materials science disciplines, biomedical research, gravitational biology, and commercial applications.

MEASURES OF PERFORMANCE

Mir research and support

Performance Metric	Plan	Actual/Current	Description/Status
Achieved six months of American crew time on Mir	Plan: 3rd & 4th Qtrs FY 1996	Actual: March - Sept. 1996	Conducted life sciences and microgravity research aboard Mir. Actually achieved seven months of American crew time on Mir.
Spacehab pressurized module to Mir	Plan: 2nd & 4th Qtrs FY 1996	Actual: March, Sept. 1996	Shuttle rendezvoused with and docked to Mir. Spacehab modules were used to transport Russian logistic items, U.S. and Russian science and technology payloads, and ISS risk mitigation payloads.
EVA spacewalk on Mir	Plan: 4th Qtr FY 1996	Actual: March 1996	U.S. performed a spacewalk while docked to Mir to validate and demonstrate assembly techniques for the ISS and installed external experiments on the docking module.

Long Duration Mission (LDM)-3	Plan: Sept. 1996 - Jan. 1997	Actual: Sept. 1996 - Jan. 1997	U.S. astronaut stays aboard the Mir space Station conducting life sciences and microgravity research.
Shuttle missions 5, 6, 7 to Mir	Plan: Jan., May, Sept. 1997	--	--
LDM-4	Plan: January - May 1997	--	U.S. astronaut stays aboard the Mir space Station conducting life sciences and microgravity research
LDM-5	Plan: May - Sept. 1997	--	U.S. astronaut stays aboard the Mir space Station conducting life sciences and microgravity research.
Shuttle missions 8, 9 to Mir	Plan: January, May 1998	--	Rendezvous and dock the Shuttle to Mir and perform crew exchange, logistics, and life science research.
LDM-6	Plan: Sept. 1997 - Jan. 1998	--	U.S. astronaut stays aboard the Mir space Station conducting life sciences and microgravity research.
LDM-7	Plan: January - May 1998	--	U.S. astronaut stays aboard the Mir space Station conducting life sciences and microgravity research.
NASA/Mir 2 Launch	Plan: 1st Qtr FY 1996	Actual: 1st Qtr FY 1996	--
NASA/Mir 3 Launch	Plan: 2nd Qtr FY 1996	Actual: 2nd Qtr FY 1996	--
NASA/Mir 4 Launch	Plan: 4th Qtr FY 1996	Actual: 4th Qtr FY 1996	--

NASA/Mir 5, 6,7 Launches	Plan: 2nd Qtr FY 1997 (Mir-5) Plan: 4th Qtr FY 1997 (Mir-7)	Plan: 3rd Qtr FY 1997 (Mir-6)	Spacehab mission management and integration functions for module Flights 5, 6, and 7 will be performed by Spacehab, Incorporated. Life sciences research on Biorack will investigate cellular functions and developmental processes in plant and animal tissues. Microgravity objectives will be focused on reducing scientific risk and enhancing long duration experiment performance and science utilization in preparation for ISS. A multi-disciplined joint U.S./RSA research program will be conducted on a continuous basis on board Mir during this period, and NASA will have a U.S. astronaut on board Mir throughout the period.
NASA/Mir-8 Launch	Plan: 2nd Qtr FY 1998	--	Spacehab mission management and integration functions for module Flights 8 and 9 will be performed by Spacehab, Incorporated. Life sciences research on Biorack will investigate cellular functions and developmental processes in plant and animal tissues. Microgravity objectives will be focused on reducing scientific risk and enhancing long duration experiment performance and science utilization in preparation for ISS. A multi-disciplined joint U.S./RSA research program will be conducted on a continuous basis on board Mir during this period, and NASA will have a U.S. astronaut on board Mir throughout the period.
NASA/Mir-9 Launch	Plan: 3rd Qtr FY 1998	--	--

Deliver and integrate final front end processors into PDSS	Plan: 4th Qtr FY 1996	Actual: 4th Qtr FY 1996	The payload data services system (PDSS) provides the data handling software and network needed to distribute data from the TDRSS users at the POIC/USOC and other remote facilities. The front end processor unit is a key element in the reception of data from TDRSS.
Deliver two STEP production units	Plan: 4th Qtr FY 1996	Revised: 4th Qtr FY 1997	Suitcase test environment for payloads (STEP) enables the verification of the payload to rack interface at remote payload development sites. First production unit was delayed to July 1997 to reflect ISS command and data handling development cycle and payload need dates.
Merge POIC/USOC and PDSS development to single Utilization Mission Support contract	Plan: 3rd Qtr FY 1996	Actual: 4th Qtr FY 1996	Payload operations and integration center (POIC) and U.S. operations center (USOC) and PDSS will gain efficiencies in development effort by a single contractor.
Complete front end processor build	Plan: 3rd Qtr FY 1996	Actual: 4th Qtr FY 1996	The front end processor unit is a key element in the reception of data from TDRSS. It converts the encoded serial steam from the ISS into the user data packets for subsequent distribution.
Complete UF-1 baseline IDRD	Plan: 2nd Qtr FY 1997	Revised: 1st Qtr FY 1998	The interface definition and requirements document (IDRD) describes the on-orbit resources (volume, power, data, etc.) allocated to all payloads
HOSC annex operational readiness date	Plan: 3rd Qtr FY 1997	--	Huntsville operations support center (HOSC) annex supports communications services for the POIC/USOC and PDSS. The annex houses the equipment to provide connection to ISS users remote locations for telescience operations.

Complete all POIC/USOC and facilities outfitting	Plan: 4th Qtr FY 1997	Revised: 1st Qtr FY 1998	Includes workstation upgrades in payload operations integration center (POIC) and U.S. operations center (USOC) at MSFC.
Complete initial ISS configuration of POIC/USOC systems	Plan: 4th Qtr FY 1998	--	POIC/USOC capabilities to support initial ISS payload operations for Utilization Flights 1 and 2. Capabilities are phased commensurate with availability of ISS flight resources.

Research facilities -- Due to the current restructuring activity, most facilities' schedules are under review

Performance Metric	**Plan**	**Actual/Current**	**Description/Status**
HRF Interim Design Review, Rack 1	Plan: 2nd Qtr FY 1996	Actual: 2nd Qtr FY 1996	This review establishes the project development plan and ensures that research/science objectives have been properly translated into statements of requirements.
HRF Preliminary Design Review, Rack 1	Plan: 3rd Qtr FY 1996	Actual: 3rd Qtr FY 1996	This review establishes the "design-to" baseline and ensures that it meets the projectbaseline requirements. 10% of the flight drawing should be complete at this stage.
HRF System Flight Design Review, Rack 1	Plan: 1st Qtr FY 1997	--	This review verifies the suitability of the design in meeting the specified requirements and establishes its "build-to" project baseline. 90% of flight drawings should be complete at this stage.
GBF Preliminary Design Review, Rack 1	Plan: 4th Qtr FY 1996	Actual: 4th Qtr FY 1996	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.

GBF Critical Design Review, Rack 1	Plan: 3rd Qtr FY 1997	Revised: FY 1998	This review verifies the suitability of the design in meeting the specified requirements and establishes its "build-to" project baseline. 90% of flight drawings should be complete at this stage.
Centrifuge Rotor and Life Sciences Glovebox Development Contract	Plan: 3rd Qtr FY 1996	Revised: Under review	In negotiations with NASDA.
FCF Core System Requirements Definition Review	Plan: 2nd Qtr FY 1996	Actual: 1st Qtr FY 1997	This review establishes full scale development plans required for go ahead for development.
SSFF Core System Critical Design Review	Plan: 2nd Qtr FY 1996	Revised: Under review	This review verifies the suitability of the design in meeting the specified requirements and establishes its "build-to" project baseline. 90% of flight drawings should be complete at this stage.
EXPRESS Rack/MSL-1 Delivery to KSC	Plan: 3rd Qtr FY 1996	Actual: 3rd Qtr FY 1996	At KSC the initial EXPRESS Rack that will fly on MSL-1 integrated with the initial payload and processed in preparation for launch in FY 1997.
EXPRESS Rack Critical Design Review	Plan: 2nd Qtr FY 1997	--	This review verifies the suitability of the design in meeting the specified requirements and establishes its "built-to" project baseline. 90% of flight drawings should be complete at this stage.
EXPRESS Pallet Project Requirements Review	Plan: 1st Qtr FY 1997	--	Review establishes the project development plan and ensures that research/science objectives have been properly translated into statements of requirements.

EXPRESS Pallet System Requirements Review	Plan: 2nd Qtr FY 1997	--	Review establishes full scale development plans required for go-ahead for development.
EXPRESS Pallet Preliminary Design Review	Plan: 2nd Qtr FY 1998	--	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
SSFF Critical Design Review	Plan: 4th Qtr FY 1997	Revised: Under review	This review verifies the suitability of the design in meeting the specified requirements and establishes its "built-to" project baseline. 90% of flight drawings should be complete at this stage.
FCF Core System Preliminary Design Review	Plan: 2nd Qtr FY 1997	Revised: Under Review	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
FCF Fluids Module Preliminary Design Review	Plan: 4th Qtr FY 1997	Revised: Under review	This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
LSE Begin manufacturing of Cold Storage Units	Plan: 3rd & 4th Qtrs FY 1996	Revised: TBD	IPR and TIMís held in FY 1996 for Quick/Snap and Cryo Storage Freezers. R/FR rephased to Flight 19A (Hab Outfitting Flight) when on-board volume becomes available.
LSE Complete General purpose glovebox manufacturing	Plan: 4th Qtr FY 1997	Actual: Cancelled	General purpose glovebox workstation for non-biological experiments in U.S. Module. This project was canceled because only one user had been identified for what was originally planned to be multi-use equipment.

Crew Health Care System (CHeCS) Complete Critical Design Review	Plan: 3rd Qtr FY 1996	Revised: 2nd Qtr FY 1997	Provides crew health care system hardware included in the health maintenance system, and the countermeasure system required to ensure crew health and safety. This activity and measure of performance was transferred from Space Station Development
CHeCS Complete manufacture and assembly of qualification hardware	Plan: 4th Qtr FY 1996	Revised: 3rd Qtr FY 1997	This activity and measure of performance was transferred from Space Station Development

ACCOMPLISHMENTS AND PLANS

Mir research and support

In November 1995, the STS-74 mission delivered a new Russian-built docking module to Mir to allow the Space Shuttle to dock in a more favorable position with the Mir. Two more Space Shuttle missions using Spacehab modules were flown to Mir in FY 1996. During FY 1996, American astronauts spent 7 months aboard the Mir station conducting life sciences and microgravity research. On the STS-76 mission, U.S. astronauts performed an extra-vehicular activity (EVA) to install external experiments on the docking module. U.S. astronaut crew training continued for upcoming flights aboard Mir.

The remainder of the microgravity experiment apparatus planned for Mir was delivered to Russia for installation in the Priroda module (March 1996) and subsequent Shuttle flights. This microgravity hardware included the Glovebox, the Microgravity Isolation Mount (MIM) (in collaboration with Canada), and biotechnology hardware to support protein crystal growth and tissue culture growth. The Space Acceleration Measurement System has continued to collect and record data to characterize the Mir microgravity environment and support the Microgravity experiments manifested on Mir.

In support of the ISS program and to take maximum advantage of the NASA/Mir opportunity, the Life Sciences Space Station Utilization program will use Space Shuttle flights to Mir to develop new technologies for life support and enhance capabilities for on-orbit quality testing and for crew restraints during medical procedures. Four of these life support and environmental systems experiments were launched in FY 1996, with remaining experiments scheduled for launch in FY 1997.

As part of the NASA/Mir Research Program (NMRP) activities in FY 1996 , the Life Sciences and Microgravity research programs continued to successfully conduct experiments to define the ISS environment. As part of the year's activities the longest spaceflight by a U.S. astronaut was achieved (143 days), aboard Mir by astronaut Shannon Lucid. The NMRP program thereby augmented previous studies on the challenges to human physiology and behavior during long-duration space flight. The program also continued with its Russian partners to standardize U.S. and Russian radiation detection data. In addition, SpaceHab, Inc.'s Commercial Middeck Augmentation Module (CMAM), outfitted with the ESA's Biorack and a suite of life sciences experiments, flew to Mir for the first time on STS-76 in FY 1996.

In FY 1997, three more Space Shuttle-Mir missions will be flown, which include three Spacehab double modules. American astronauts will spend 12 months aboard Mir conducting research and gaining more long-duration space flight experience. On the seventh Mir mission (STS-86), there will be an EVA to remove external experiments from the docking module. The program will use the NMRP to further study the physiological and behavioral changes that occur during long-duration space flight. The NMRP in FY 1997 will also provide U.S. extramural investigators with continuing opportunities to conduct plant and animal investigations, including the second and third Biorack flights.

Systems engineering efforts will continue to support methodologies for advocacy and coordination of U.S. research requirements and implementation of processes and tools for mission planning for US payloads on future space platforms, primarily the phase II and III of the ISS. Space Station planning and integration efforts will intensify as the First Element Launch date of the ISS approaches (December 1997).

During FY 1998, two Shuttle flights to Mir will be flown which will include a Spacehab double module and a single module. American astronauts will spend 8 months aboard Mir conducting research. It is anticipated that the Mir Phase 1 program will be completed with the ninth Shuttle flight to Mir in May 1998. The Life Sciences and Microgravity research programs will continue science investigations aboard Mir through FY 1998. Life Sciences expects to conclude its participation in the NMRP with a successful suite of research and development results in human physiology and behavior and in animal and plant biology.

Utilization support

During FY 1996, the design and development of the payload training capability at the Johnson Space Center (JSC) and the physical integration capability at the Kennedy Space Center (KSC) were completed. The initial delivery of the POIC/USOC at the Marshall Space Flight Center

(MSFC) was completed, as was the design of the initial PDSS capabilities. A demonstration of the payload data library (PDL) concept occurred in early FY 1996 and was followed by the start of full-scale development. Development of the Payload Rack Checkout Unit (PRCU) also began.

In FY 1997, development of the POIC/USOC and PDSS capabilities for initial ISS support will begin based on the completed designs. The PDL and PRCU will both complete development in FY 1997. Payload engineering for early Utilization flights will begin, including establishment of a template for each of the six utilization flights, operating plans, and wiring diagrams. In mid-FY 1997 payload training plans will be issued. Two of ten suitcase test environment for payload (STEP) units will be complete and available for shipment to users and payload development sites in support of the early ISS utilization flights. Payload integration agreements will be baselined for UF-1 payloads.

In FY 1998, the initial software capabilities for the POIC/USOC to support initial ISS Utilization Flights 1 and 2 will be delivered. Outfitting of the POIC/USOC with equipment to support ISS operations and training will also occur in FY 1998. Development of initial PDSS capabilities in support of ISS Utilization Flights 1 and 2 will be completed and the system will be completing final verification in support of a delivery in the 1st Qtr of FY 1999. In addition, design and development for final POIC/USOC and PDSS capabilities will be initiated at the end of FY 1998.

Research facilities

The HRF project considered various procurement and development strategies during FY 1995 and determined that existing flight hardware can support the project's early research requirements adequately. The HRF activities will include modifications to existing flight hardware during FY 1996 and FY 1997. New hardware will also be developed, but it has determined that no prime contracts for major hardware development will be necessary during the project's life. JSC plans to rely upon its in-house contractor, Lockheed-Martin, for hardware engineering and development support.

During FY 1995 and early FY 1996, the HRF project finalized its science requirements through the HRF's science working group. In FY 1996, the project began modifying and developing HRF precursor research equipment to fly on the last two NMRP missions. The project will develop procedures for conforming to Russian policies and procedures related to biomedical monitoring and countermeasures. The HRF project will also proceed with the development of hardware for the first rack to support an FY 1999 launch. Beginning in FY 1996, the HRF project held meetings with the international community to discuss sharing hardware development for the first two racks. NASA anticipates that sharing arrangements with the ISS international partners for HRF hardware development will yield efficiencies and minimize hardware redundancies. The HRF project completed an interim design review for the initial rack system for the second quarter of FY 1996. It conducted a preliminary design review for the first rack during the third quarter of FY 1996. During the first quarter of FY 1997, the HRF project expects to conduct a system level final design review.

The HRF project also has responsibility for provision of the Crew Health Care Subsystem (CHeCS). CHeCS will provide for medical care for the ISS crew following deployment of the U.S. Laboratory module in late 1998, and will provide medical care, operational exercise, countermeasures and environmental monitoring aboard the ISS. In assuming the CHeCS responsibility, hardware commonality between CHeCS and the HRF will be evaluated, with the synergy between the two programs resulting in efficiencies and cost savings.

During FY 1995, the GBF focused on developing detailed system specifications for equipment and system-level designs for the project's space and ground segments. A rack level preliminary design review was completed in the fourth quarter of FY 1996, to be followed by a rack level critical design review during the third quarter of FY 1997. During FY 1996, GBF project activities also focused on developing various habitats that will integrate into the initial rack, e.g., incubator and cell culture units. Other GBF activities will include the development of habitat science evaluation hardware for testing by the science community. These science tests will evaluate science utility of the GBF habitat designs. The first complement of GBF hardware is scheduled for flight in FY 1999, with a second rack scheduled for FY 2002.

During FY 1996, the CF project supported negotiations with NASDA to build the CF rotor and the life sciences glovebox. The project will continue in-house hardware development and test bedding at ARC, and it will proceed with science requirements definition. A rodent metabolism study now being performed by the Bioenvironmental Research Laboratory at the University of Illinois at Urbana-Champaign will continue, as will the rodent acoustic tolerance testing being done at San Jose State University. Life sciences established a combined CF/GBF science working group during FY 1995 to conduct a variety of new studies in support of both the GBF and CF activities. The CF project will continue to support science studies to evaluate and improve upon hardware designs and configurations.

In FY 1996, the BTF experiment control computer flew on Mir to control cell and tissue culture experiments. The Mir precursor flights will reduce the risk in the design and development of full facility operations for Space Station. The BTF Requirements Definition Review scheduled for FY 1996 was delayed. The project schedule is currently being reevaluated.

The combustion and fluids modules for the FCF completed their Requirements Definition Review in October 1996. After successful completion of the review, the facility will proceed to the preliminary design and development phase. The preliminary design review, scheduled for FY 1997, is under review. The current launch readiness date for the FCF is the third quarter of 2001.

The SSFF core will be fabricated after the Critical Design Review. Originally scheduled for December 1996, the facility schedule is under review. The current launch readiness date for the Core facility and the first instrument rack is the second quarter of FY 2002.

The hardware that is being developed for risk mitigation includes a treadmill (with vibration isolation technology), a heart rate monitor, a blood pressure and ECG monitor, and a cycle ergometer. Some of this equipment will be located in the Russian modules in order to provide required capabilities to support permanent human presence prior to assembly of the U.S. laboratory module. The development of this equipment is planned for completion by the end of FY 1997, in time for early deployment during the ISS assembly phase.

During FY 1996, testing and integration of the MSL-1 EXPRESS rack was completed, and the rack was delivered to the KSC for payload integration and launch processing. Design was completed for the Space Station EXPRESS rack configurations and assembly of hardware was initiated for qualification and acceptance testing. In FY 1997, the MSL Spacelab mission will demonstrate operations of science payloads on orbit using an EXPRESS rack. Fabrication and testing of the first EXPRESS rack to fly on the ISS will begin in FY 1977 to support launch readiness for the first ISS utilization flight in FY 1999. EXPRESS rack interface simulators will be fabricated for use by EXPRESS payload developers.

During FY 1997, the design specifications for the EXPRESS pallet will be completed and approved at the Systems Requirement Review. Preliminary design will be completed and the PDR will occur in FY 1998. The first two EXPRESS pallets will be delivered to KSC in FY 2000 where integration with the six payloads will occur. The EXPRESS pallets flight readiness is scheduled in FY 2001.

The Stratospheric Gas and Aerosol Experiment (SAGE III) is scheduled for flight in 2001 and will take advantage of both solar and lunar occulations to measure aerosol and gaseous constituents of the atmosphere. Ball Aerospace is responsible for development, and the instrument began Phase C/D development in November of 1994. Activities have progressed on schedule with the CDR completed in August 1996.

During FY 1997 and FY 1998, NASA's commercial research programs for the ISS will concentrate on Commercial Protein Crystal Growth, where the intent will be to increase the number of samples that can be processed in a given volume, to monitor and control growth conditions, and to develop a new generation of thermal enclosures for crystal growth. NASA's commercial protein crystal growth activities for ISS are underway at the Center for Macromolecular Crystallography. NASA's FY 1997 and FY 1998 commercial research programs for ISS will also emphasize plant growth research, where the activities of the Wisconsin Center for Space Automation and Robotics, the Center for Bioserve Space Technologies, and their industrial affiliates will use ISS to develop heartier and more resistant plant products and to attain pharmaceutical advances using plants. The Integrated Space Station Engineering Center (ISSEC) will issue a cooperative agreement in the first quarter of FY 1997. Proposals for the ISSEC are planned for the second quarter of FY 1997, with evaluations to be completed in the third quarter of FY1997.

Science utilization

Life Sciences Space Station utilization activities will support the infrastructure development for Life Sciences Research facilities. Activities include developing initial training plans, preliminary definition of User Operation Facility requirements, experiment management approaches, initial crew procedures, baseline logistics, and the development of baseline data collection requirements for biomedical research. Life Sciences Space Station utilization also provides training for crew procedures and real-time operations, and supports the development of sustaining engineering and logistics systems and processes, experiment reviews, and the preparation of ground operations documentation.

The Microgravity Sciences program consists of planning and integration activities, developing operations support procedures, and developing experiment unique research hardware for the ISS. The microgravity program has continued the definition, design, and development of its Space Station facilities to meet its long-term program goal to deploy several multi-user facilities specifically designed for long-duration scientific research missions aboard the International Space Station. To prepare for microgravity operations on the ISS, work continues to define operational requirements and develop telescience techniques. Operational capability for microgravity research will be developed at MSFC, JSC, LeRC, and JPL.

Hardware design efforts will continue for the Physics of Colloids in Space (PCS) experiment. The science objectives are to create novel structures from colloidal particles and to study the dynamics of their formation and physical properties. The experiment will include studies of binary mixtures to form ordered and disordered structures in the formation of fractal colloidal aggregates. This is a follow-on to the PHaSE experiment scheduled to fly on the March 1997 MSL-1 mission that will take advantage of a significant design heritage. The PCS is planned to be the first Fluid Physics discipline experiment to be conducted on the ISS and launched on one of the early utilization flights.