The International Space Station: A Pathway to the Future

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ABSTRACT

Nearly six years after the launch of the first International Space Station element, and four years after its initial occupation, the United States and our 16 international partners have made great strides in operating this impressive Earth orbiting research facility. This past year we have done so in the face of the adversity of operating without the benefit of the Space Shuttle.

In his January 14, 2004, speech announcing a new vision for America's space program, President Bush affirmed the United States' commitment to completing construction of the International Space Station by 2010. The President also stated that we would focus our future research aboard the Station on the long-term effects of space travel on human biology. This research will help enable human crews to venture through the vast voids of space for months at a time. In addition, ISS affords a unique opportunity to serve as an engineering test bed for hardware and operations critical to the exploration tasks. NASA looks forward to working with our partners on International Space Station research that will help open up new pathways for future exploration and discovery beyond low Earth orbit.

This paper provides an overview of the International Space Station Program focusing on a review of the events of the past year, as well as plans for next year and the future.

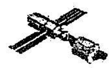
THE *COLUMBIA* ACCIDENT'S EFFECTS ON ISS

The loss of the Space Shuttle *Columbia* and its crew was devastating for the entire NASA family. For the International Space Station Program, finding our way through this tragic loss begins with an unwavering commitment to learn from the tragedy

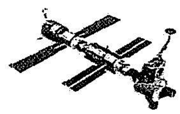
Columbia serves as a reminder that space flight is harshly unforgiving of engineering deficiencies, overconfidence, systems or human error, or inaccurate risk assessments. The ISS Program's efforts over this last year have required us to continue to identify, understand, control, mitigate, and contain risks while accomplishing the mission entrusted to us of building, operating and performing research on the Space Station effectively and safely.

Although the grounding of the Shuttle has provided a challenge to ISS operations, the spirit of the partnership that built the ISS has sustained it through this difficult period. The ISS International Partnership stepped up to the challenge of keeping the ISS operating safely with people aboard.

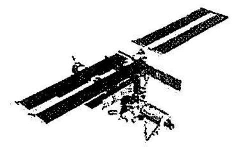
The year 2003 was planned to be an aggressive one as we completed assembly of the truss structure, including installation of the remainder of the truss and solar arrays. Many of these truss elements were heavy and required all of the capabilities of the Shuttle to lift them. For this reason, by the start of 2003 the ISS was pre-stocked with crew supplies and propellant to ensure that crew needs could be met. This proved fortuitous.



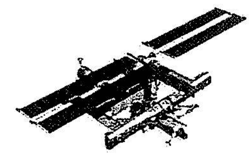
Zarya/FGB and Unity Node 1
1998



Zvezda Service Module and Z-1 Truss
2000

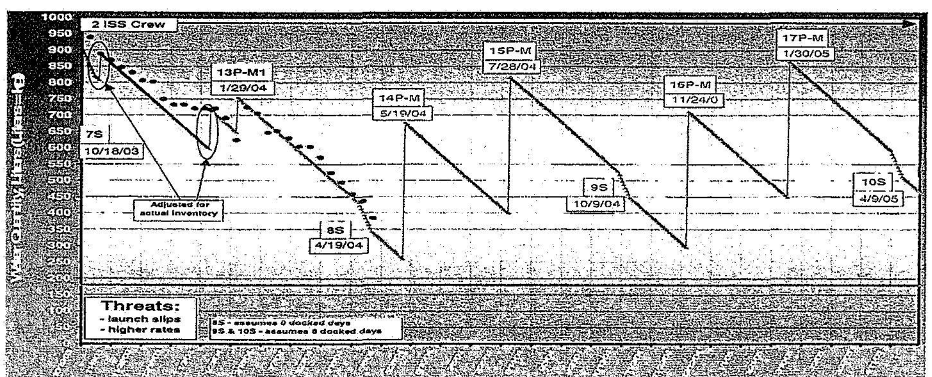


Destiny Lab, CanadArm2 and Quest Airlock
2001



P-1 truss Current Configuration
2003

Further loss of the resupply and return capability afforded by the Shuttle has forced the program to pay extreme detail to resupply, research, and logistics. Critical consumables such as water and critical spares had to be planned months in advance. The initial uncertainty associated with the Shuttle return to flight made us plan for an undefined interval. This was difficult and the teams had to develop new ways of thinking and planning. The crew size was reduced from 3 to 2 to allow the ISS to remain crewed. We have managed to maintain a two-person crew on the ISS, depending upon Russian Progress spacecraft to supply cargo and remove trash and waste, and on Soyuz spacecraft to rotate crews. In many ways this reduced resupply capability is preparing us for exploration where the supply capability will be limited by distance. Science and research are still being performed on ISS even with this reduced crew and reduced resupply capability.



Critical consumables are being carefully tracked and forecast

The ISS is a large, complex spacecraft that must be maintained by its crew. Similar to spacecraft that will support future missions beyond low-Earth orbit, ISS does not return to the ground for servicing, and provisioning of spares is severely constrained by transportation limits. Although significant technical support is provided by ground personnel, all hands-on maintenance tasks are performed by the crew.

The lifespan of hardware is frequently limited by performance and materials constraints. Hardware of the ISS may be designed to remain in orbit without maintenance or replacement, designed for periodic maintenance or replacement, or designed with a specific certification lifespan. The ISS Program uses a combination of analysis, testing, or simulations to define the life limits.

The focus of the current logistics and resupply effort is to maintain and sustain the ISS and to conduct safe operations during the Shuttle downtime. The goal is to keep ISS in an assembly ready configuration. Spares provisioning and other logistics efforts must still be maintained in an adequate manner, and this requires a focus on any systems that support crew health maintenance including the environmental control systems, monitoring equipment, and exercise hardware.

Some very valuable lessons have been learned as a result of the conditions imposed in the wake of the loss of Shuttle support. In the case of avionics, software upgrades have continued for systems still in orbit. Virtually all of the Space Station's U.S. and Russian software has been upgraded at least once since February 2003. The effort has shown advantages over the nominally planned process; it facilitates living within the budget allocations by simply adhering to the software staffing plan established assuming a continuous stream of flights. In addition, the number of software bugs gets continuously reduced in a steady process, allowing the operations organization to remove workarounds in procedures at a predicable rate. About half the workarounds identified for software issues are expected to be eliminated through calendar year 2004.

As a result of restricted logistics capacity the conservation of provisions has been increased. This includes the reduction in usage rates, use of all allotted consumables and the improvement of utilization planning. The iterative process of tying analysis of use to projections for new requirements is now much more closely managed. Requirements are analyzed, usage rates and resources closely tracked, projections adjusted, and the information gained as a result folded into planning for future logistics support.

Detailed tracking of food consumed vs. planned consumption is maintained continuously. Prior to the accident, overage of 20-25% food was routinely packed; now it is managed much more closely. Clothing has been reduced from 12 to 2 cu ft per crewmember. Frequently, soft goods such as clothing and towels are now used as the packing material for other more sensitive hardware being launched. Office supplies and film has been reduced to the maximum extent. Digital imagery which can be downlinked to the ground is used more extensively in place of film. Procedures and documentation typically was carried in printed form and occupied up to 2 cu ft per increment prior to the loss of the Shuttle; now, with the exception of emergency procedures, most procedural information is carried electronically. The on-orbit drying of towels contributes to conservation not only of the provisions, but also aids in the recycling of water through the closed U.S. and Russian water systems and has reduced consumption from 3 to 2 liters per day per person.

Analysis and testing of the useful life of consumables such as filters used in the environmental control system have reduced resupply requirements for the Sorbent Bed Assembly, High Efficiency Particulate Air (HEPA) Filters, Lithium Hydroxide (LiOH) carbon dioxide reduction filters, and the Extravehicular Maneuvering Units (EMUs). Environmental monitoring systems for air and water quality that were provided in the past by both Russia and the U.S. have now been consolidated into a single set of samples. The U.S. has also developed smaller sampling systems. These changes significantly reduce the number and mass of samples returned to the Earth for analysis.

Degraded environmental monitoring systems, such as the Mass Constituent Analyzer (MCA) have had to be used infrequently for only the most critical measurements. The loss of the Volatile Oranics Analyzer required the development of an agreement to cooperate with our Russian partners in sharing returned samples for analysis and monitoring of the atmosphere. In-situ water microbiological measure now are made to verify water quality and samples are not generally returned to earth for analysis.

A major challenge has proven to be the inability to return failed hardware to the ground for failure analysis and refurbishment. In the case of the failure of the Control Moment Gyro-1, while the remainder of the CMG system can continue to maintain vehicle attitude control the cause of the failure of its rotational bearing and the implications for the long term acceptability of the design have not proved resolvable by a combination telemetry analysis, computer simulation and ground tests.

Hardware changes and maintenance operations have been made to the Resistive Exercise Device and the Treadmill systems. The systems are now being maintained through the replacement of much smaller components than had been planned for the systems. In many cases these changes increase maintenance activities and crew time requirements, and they require the crew to deal at lower component levels than had been planned pre-accident, but reduces the launch mass required to support maintenance.

Treadmill (TVIS) and Cycle Ergometer (CEVIS)Vibration Isolation Systems

These techniques and processes will all be used for exploration. The techniques that we are now using out of necessity will again be needed for exploration.

The lack of Shuttle down-mass capability has increased stowage requirements on the Station. New stowage volumes, including the backs of racks and unused volumes in systems racks have been found and utilized. In many instances, hardware that would otherwise have been returned for analysis or refurbishment has instead been disposed of on Progress freighters. In the case of laptop computers, the causes of failures may never be known as the hardware was disposed of on reentering Progress vehicles.

Electron oxygen, Control Moment Gyro (CMG), Extravehicular Mobility Units (EMU) during maintenance, and EMU pump impeller generation unit

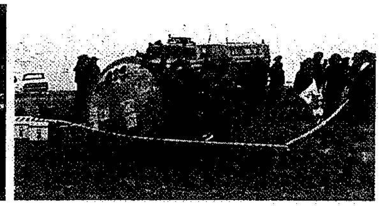
For future spacecraft, more efficient inventory management systems and increased use of downlinked telemetry to permit the ground to assist in inventory control could reduce crew time and ascent/return requirements. Further generic tools to troubleshoot, repair, and analyze scientific results will be required for exploration. ISS is again serving as a test bed for exploration. Evaluation of results on location will be a tremendous asset.

To ensure that we have the logistics and confirm the Shuttle flight capability necessary to support the ISS crew and continue assembly once Shuttles return to flight, NASA has added a flight to the manifest. The new flight, STS-121 (ISS ULF 1.1) will accomplish some of the ISS utilization and logistics objectives from STS-114, (ISS LF-1).

EXPEDITION CREWS CONTINUE WITH DAILY LIFE ON ISS

The Expedition 6 crew was in residence on the ISS at the time of the *Columbia* accident, having arrived on the STS-113/11A flight in November 2002. This crew of three included Commander Ken Bowersox, Science Officer Don Pettit, and Flight Engineer Nikolai Budarin.



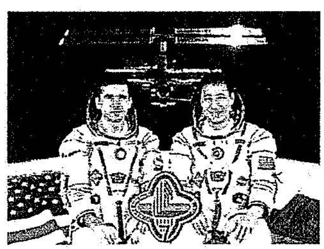
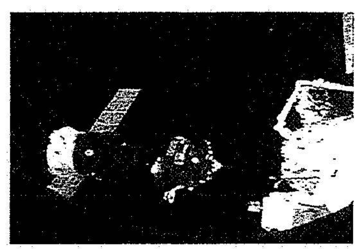


Their long list of accomplishments include repairs to Microgravity Science Glovebox and ARCTIC freezer as well as conducting 23 (a combination of new and continuing) scientific experiments. The crew also participated in the largest ever major software upgrades for both the U.S. and Russian segments of ISS.

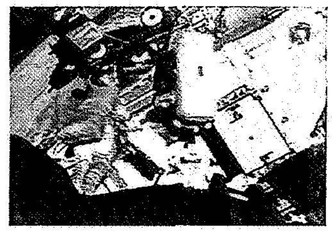
The Expedition 6 crew conducted two EVAs from the Quest Airlock. During the first, they deployed a thermal radiator on the P1 Truss and cleaned debris from the seals on the port of the Unity Module where the Multipurpose Logistics Modules are berthed. A second EVA included the reconfiguration of control moment gyroscope cables and preparation of the ISS for future assembly enhancements.

Science Officer Don Pettit shared some inspiring and educational moments with all of his Earthbound friends in his letters and videos known as "Don's Space Chronicles" and "Saturday Morning Science" about life and research on ISS. Since the return of the Expedition 6 crew, NASA has prepared a series of videos for educational use based on Pettit's work in orbit.

Following handover of ISS to the Expedition 7 crew, the Expedition 6 crew returned to Earth on the Soyuz vehicle that had been docked to ISS during their mission. The two U.S. crew members became the first Americans to return to Earth on a Soyuz spacecraft. As a result of a system anomaly, the Expedition 6 Soyuz vehicle experienced a ballistic reentry and landed several hundred miles from the prime landing site. The ballistic entry caused a short delay in the Russian Rescue forces locating the crew, but the crew was recovered safely and in great shape. Procedures have been modified to better support a ballistic entry if one were to occur in the future. The cause of the Ballistic entry has been determined and changes were made to future Soyuz Spacecraft.

The Expedition 7 crew, the first two-person crew on the ISS, launched in a Soyuz spacecraft on 26 April 2003, and docked to the ISS two days later. The Expedition 7 consisted of Commander Yuri Malenchenko and Science Officer Edward Lu. The only visiting spacecraft that arrived during the Expedition 7 mission were two Progress resupply craft. The Expedition 7 crew had no human visitors during their mission until the Expedition 8 crew, Commander Michael Foale and Flight Engineer Alexander Kaleri, arrived together with ESA astronaut Pedro Duque from Spain, onboard a Soyuz spacecraft in mid-October. Duque returned with the Expedition 7 crew after spending 8 days on ISS conducting experiments.

The Expedition 8 crew launched on the 7th Soyuz to visit ISS, on October 18, 2003, and docked to the ISS two days later. The crew consisted of ISS Commander and Science Officer Mike Foale, and ISS Flight Engineer and Soyuz Commander Alexander Kaleri. Foale and Kaleri received a handover of ISS operations from the Expedition 7 crew, Commander Yuri Malenchenko and Flight Engineer and Science Officer Ed Lu. The 7-Soyuz vehicle also brought ESA Astronaut Pedro Duque, who performed a Visiting Crew mission for Spain during the Expedition 7-to-8 crew handover. Duque returned to Earth with Malenchenko and Lu on the 6-Soyuz vehicle, landing on October 28, 2003.

Foale and Kaleri performed the first EVA from ISS without the presence of an Intravehicular crewmember. This Russian EVA, in Orlan spacesuits from the Pirs airlock, completed objectives for ESA (Matrioshka) and JAXA (MPAC/SEEDS). The EVA was terminated early due to a cooling problem in Kaleri's spacesuit, before the ESA objective of ATV retroreflector rearrangement could be accomplished.

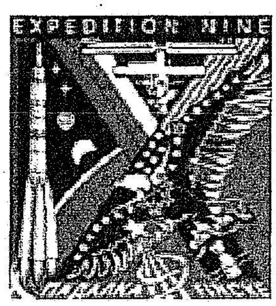
Expedition 8 faced many challenges. The Treadmill Vibration Isolation System (TVIS) gyroscope failed early in the Increment. Foale and Kaleri successfully performed an extensive In-Flight Maintenance to take apart the gyroscope and replace the bearings. A flexible hose failed on the U.S. Laboratory window, allowing a slow leak of air overboard. The crew was required to isolate ISS modules by closing hatches for a weekend to verify that removal of the hose stopped the leak. The Elektron O2-generation system failed during the Increment, requiring replacement of two Elektron units. The atmosphere was maintained by gas from the Progress vehicle and by using Russian Solid Fuel Oxygen Generator units. [these could be expanded and tie lessons learned directly to exploration]

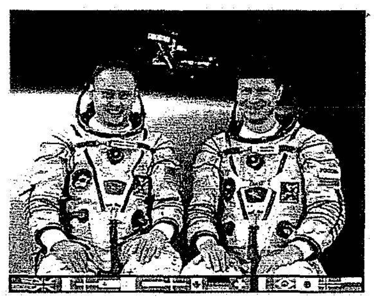
During Expedition 8, only one Progress cargo vehicle visited the ISS. There were no human visitors until the Expedition 9 crew arrived on 8-Soyuz on April 21, 2004. The Expedition 9 crew consisted of ISS and Soyuz Commander Gennady Padalka and ISS Flight Engineer and Science Officer Mike Fincke. They were joined by ESA Astronaut Andre Kuipers, who performed a Visiting Crew Science Program for The Netherlands during the handover. Foale, Kaleri and Kuipers returned on the 7-Soyuz vehicle on April 30, 2004.

On April 21, 2004, during the docked mission, the Remote Power Controller Module (RPCM) that supplies the power for Control Moment Gyro (CMG)-2 failed, removing power to the CMG. Planning for an Extravehicular Activity (EVA) to change out the RPCM started immediately. During the checkout of the U.S. Extravehicular Mobility Unit (EMU) suits, EMU #3005 failed to provide cooling. Troubleshooting was performed on #3005 and also on #3013, which had previously been declared failed, but cooling could not be restored on either suit. With no U.S. EMU capability, planning for the EVA shifted to use of the Russian Orlan suits. The initial attempt to perform the RPCM change-out EVA, in Orlan suits, occurred on June 24, 2004. This EVA was terminated in just over 14 minutes due to a loss of Oxygen pressure in Fincke's suit. The anomaly was traced to a slight defect in the flow control valve that allows the flow to continue, although the display indicated flow was closed. A procedural change was implemented and the EVA was successfully performed on June 30, 2004.

The RPCM change-out EVA was a shining example of multilateral cooperation, as this was the first EVA to be performed in Russian suits on the U.S. segment. The Russian Flight Control Team was in control of the EVA while the crew was on the Russian portion of the Station. The U.S. Flight Control Team was in charge of the operations on the U.S. Segment, although the Russian Team remained in charge of monitoring crew health and Orlan suit status. The handovers between the Flight Control Teams, including language swaps as the crew translated from the Russian to U.S. Segment and back, was flawless. The EVA was completed in 4 hours 30 minutes, including installation of some EVA translation equipment on the exterior of the Russian Pirs airlock that had been planned for later EVAs. During the EVA, the CSA developed Space Station Remote Manipulator System was used to monitor the status at the RPCM worksite.

There were originally two EVAs planned to be performed during Expedition 9, with the addition of the RPCM EVA, three full duration EVAs will be performed. The first EVA of the preflight planned EVAs was conducted on August 3, 2004. This EVA included several tasks to outfit the Service Module (SM) in preparation for the future arrival of the Automated Transfer Vehicle being developed by ESA, including antenna and rendezvous laser reflector installations. Changeout of a Kromka panel and removal of the PLATAN payload were also performed. This EVA was performed following the 14Progress undock and prior to the 15Progress dock to provide access to some areas that cannot be reached with a vehicle on the SM aft end. The EVA was completed in 4 hours and 29 minutes. The second of the planned EVAs is currently scheduled for September 3, 2004, and will include additional ATV outfitting tasks, as well as replacement of a Functional Cargo Block coolant flow control valve panel.





Two Progress vehicles arrived during the increment to deliver cargo. There have been no visiting crew operations during the increment. During Expedition 9, Astronaut Mike Fincke continued the 'Saturday Science' downlinks initiated more than a year earlier on Expedition 6. These "Saturday Science" activities are significantly different than those performed by Don Petit. The new "Saturday Science" is planned expedition science being done on the crew's free time on Saturday. This allows for a more relaxed pace of science investigation. This planning technique may prove to be an effective to utilize ISS and perform science in a more research type environment. In Don's science the activity were simple physics experiments based on materials at hand. These experiments were not formally planned, but will serve as catalyst for new experiments. The time available on ISS may be transforming the planning and method of doing remote research in space. In a space first, Fincke's wife Renita gave birth; this is the first time a father was in orbit for his child's birth.

The Expedition 10 crew is scheduled to arrive on October 11, 2004. Following the handover mission with Expedition 10 ISS Commander and NASA Science Officer Leroy Chiao and ISS Flight Engineer Salizhan Sharipov, the Expedition 9 crew will depart the ISS and return to Earth on October 19, 2004.

ISS ASSEMBLY AND HARDWARE PROCESSING

At the time of the *Columbia* tragedy in February 2003, the ISS Program was making excellent progress toward meeting the challenges of assembling the greatest research facility in orbit. During 2002, more than 90,000 pounds of hardware had been launched to the ISS resulting in the largest, most complex space station in history weighing 404,000 pounds and having 15,000 cubic feet of habitable volume.

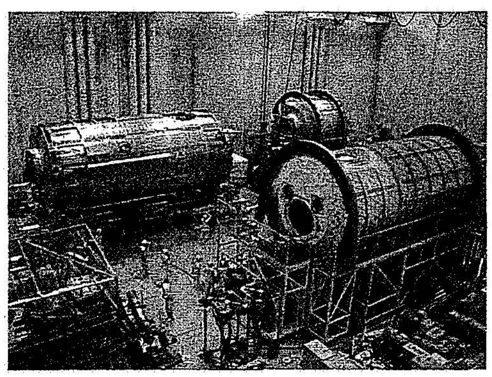
The ISS is halfway to the international partner core complete configuration and now includes the following elements: FGB (Zarya), Node 1 (Unity), 3 Pressurized Mating Adapters, Service

Module (Zvezda), U.S. Laboratory (Destiny), U.S. Airlock (Quest), Russian Docking Compartment (Pirs), CanadArm 2, Mobile Base System, Mobile Transporter, Z1, S0, P1, and S1 truss segments, and the P6 Solar Array.

ISS assembly operations on orbit were brought to a virtual standstill by the grounding of the Space Shuttle fleet. The Shuttle is the only spacecraft that has the capability to deliver to orbit the large US, Japanese and European ISS elements, such as the modules, trusses and solar arrays that will be launched to complete the assembly of the ISS.

The ISS Program is taking the steps necessary to be in a posture to continue assembly immediately upon the Space Shuttle's return to flight.

A process was implemented to maintain the charge of the banks of nickel hydrogen batteries mounted on the truss segments that are awaiting launch. On orbit, these large batteries are charged by the solar arrays to store the electricity used to power the ISS while it is in the shadow portion of its orbit. Following careful review of the costs and technical implications of various options, it was decided to allow the batteries to remain integrated on the truss and maintain their chart with boost



Upon the Space Shuttle's return to flight, priority will be given to safe return of the Shuttle to flight, launching backlogged U.S. research and preventative maintenance hardware and repairing the failed Control Moment Gyro (CMG) onboard ISS. The ISS and Space Shuttle Programs are working closely to tailor the flight manifests to accommodate the critical priorities.

charging. This plan is carefully being reviewed as the ground storage time increases.

Careful monitoring of hardware for possible storage and certification life issues is continuing to ensure that the ISS hardware is ready to support assembly when the Space Shuttle flights resume. Solar array wing P4 (the oldest of those awaiting launch) was returned to the manufacturer for deployment testing since it was near the end of its projected storage certification life. This wing had to be removed from its flight ready configuration and shipped to California for testing to insure there were no adverse effects of storage. One concern was that with time, the glue that holds the solar cells to the array undergoes changes, which can result in increased adherence between the panels. This action extended the storage life of the solar arrays to meet all planned Shuttle return to flight dates.

All remaining U.S. Core hardware, Node 2, the Japanese Experiment Modules and the ESA Columbus module are at KSC. Hardware development and processing at Kennedy Space Center (KSC) has continued. More than 279,000 pounds of hardware has been processed and is ready for launch in Florida, and another 174,000 pounds of hardware is staged in other international locations.

There will be ascent performance losses for the Space Shuttle orbiters that are associated with the new requirements to fly the Space Shuttle robotic arm and tile/wing leading edge repair capability on each flight, resulting in a reduced ISS cargo delivery capability. Lowering the ISS orbital altitude for Shuttle dockings will help address this issue and maintain the ability to deliver to orbit the large pieces of hardware such as trusses, solar arrays, and laboratories that will complete the assembly of ISS. In the ISS assembly sequence, there are a minimum of 28 more Space Shuttle flights required to reach international core complete.

A piece of critical hardware that will be given top priority is the replacement control moment gyroscope (CMG) that will be delivered to ISS on the first Shuttle mission following return to flight. There are four CMG's mounted in the Z1 truss on ISS that provide nonpropulsive attitude control for the Station. At the present time only three are operational, but in its current configuration, the ISS can maintain attitude control with two

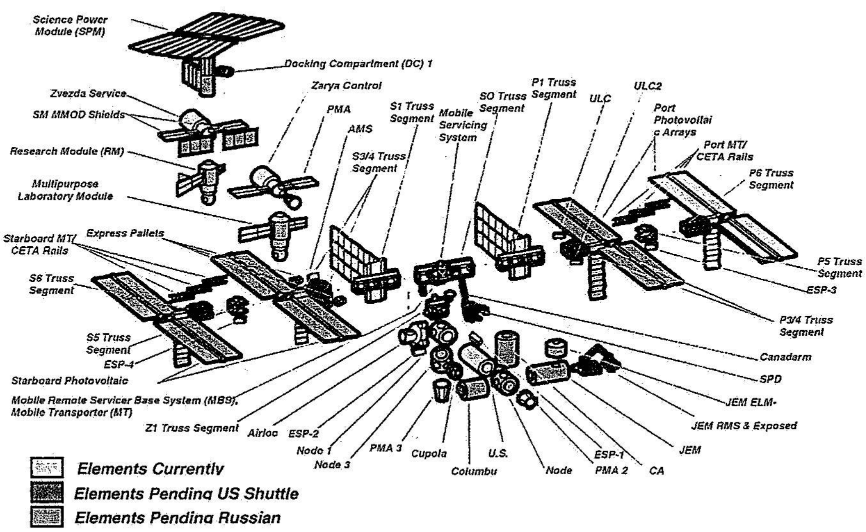
CMG's. The failed CMG that has experienced a bearing failure will be returned to Earth for analysis by the Space Shuttle flight that delivers its replacement.

When the assembly flights begin, the ISS will face its most complex and challenging period of assembly. The remaining integrated truss segments, solar arrays, Node 2, and the international laboratories will be delivered to bring the ISS to the International Core Complete configuration.

During the first several assembly missions, the operation of key distributed systems on ISS will be dismantled and reconstructed. The temporary power and thermal systems now in use will be disconnected following activation of the permanent systems located in the trusses and the assembly and activation of three new solar arrays. One of the very challenging tasks of this period is the retraction of the P6 Solar Array, the movement of the P6 truss to its final outboard position from the temporary position where it is now extends upward from the Z1 truss, and the redeployment of the array.

During the 2004 Heads of Agency Meeting the space agency leaders from the United States, Russia, Japan, Europe and Canada met at the ESA Technical Centre (ESTEC) in Noordwijk, The Netherlands, to discuss International Space Station (ISS) cooperation activities. At the meeting, the ISS Partnership unanimously endorsed the ISS technical configuration and reviewed the status of ISS on-orbit operations and plans. The new ISS configuration is planned for completion by the end of the decade and will accommodate on-orbit elements from each of the ISS Partners. The configuration will enable increased utilization and will provide early opportunities for an enhanced crew of greater than three people.

ISS Assembly Complete



The ISS Partnership's endorsement of this configuration provides a clear basis for completion of programmatic and financial evaluation and subsequent agreement on a transportation and logistics framework that will support assembly and operation of ISS. This framework will be supported by Russian Soyuz vehicles, the U.S. Space Shuttle, the automated logistics resupply and re-boost capabilities provided by Russian Progress vehicles, and the transfer vehicles ATV and HTV to be provided by Europe and Japan.

The partnership also agreed that additional assessments would be conducted to confirm the ISS flight program in a nominal mode in 2005 and further to evaluate opportunities to accelerate the launch of the Japanese and European research modules JEM

(Kibo) and Columbus and to establish a specific schedule to enhance the permanent crew.

NASA and FSA (Russian Federal Space Agency) once again reconfirmed their commitment to support individually and cooperatively, in 2005, uninterrupted (continuous) human presence on the ISS of the integrated crew, provide for its rotation, and rescue on a parity basis. For that they agree to complete agreements on mutual responsibilities for ISS as soon as possible. The results of these assessments will be reviewed at the next ISS Heads of Agency meeting in early 2005 leading to the partnership's final endorsement of the ISS configuration.

During their discussions, the space agency leadership reaffirmed their enduring commitment to the unprecedented international cooperation that has characterized the ISS Program. In particular, they expressed their appreciation of Russia's significant efforts, through the provision of crew transportation and resupply capabilities, to safely maintain a human presence on-orbit during the current hiatus in Space Shuttle flights.

They also expressed appreciation for NASA's continuing efforts to safely return the Space Shuttle to flight in the March 2005 timeframe as a significant step for continuing ISS assembly and operations.

CONCLUSION

Since the *Columbia* tragedy, the ISS international partnership has allowed the ISS to continue fulfilling its mission to understand and protect our world, to explore the universe, and to inspire the next generation.

NASA is embarking on a new and exciting chapter in space exploration. The new vision for space exploration calls for a sustained, achievable, and affordable human and robotic program to explore the moon, Mars and beyond. The ISS now plays an even more critical role in paving the way for human space exploration beyond low Earth orbit. The President has given NASA the goal to complete assembly of the ISS by the end of this decade and to re-focus U.S. research and use of the ISS on supporting space exploration goals, with emphasis on understanding how the space environment affects astronaut health and developing countermeasures and spacecraft systems, such as those for life support.

The Space Station serves a wide variety of purposes. It is a microgravity and life sciences laboratory, a test bed for new technologies in areas like life support and robotics, and a platform for astronomical and Earth observations. It is the cornerstone of the vision for space exploration. Assembling and operating the International Space Station has been producing advances in our knowledge about how we can live and work in space for long, continuous periods of time, and even the unfortunate loss of *Columbia* and Shuttle logistics support has been a tremendous lesson in how to support extended missions at planetary distances. The knowledge we are gaining is critical for our future journeys.

NASA embodies the human spirit's desire to discover, to explore, and to understand. The Space Shuttle and International Space Station are not viewed as ends in themselves, but the means to achieving the broader goals of the nation's space program. Transportation and orbital facilities support and enable our efforts in science, exploration and enterprise.