The Space Congress® Proceedings | 1997 (34th) Our Space Future - Uniting For Success

Apr 30th, 1:00 PM

Paper Session II-B - The International Space Station: Background and Current Status

Daniel V. Jacobs
Manager, Russian Integration, International Partners Office Space Station Program, NASA

SPACE CONGRESS 1997
THE INTERNATIONAL SPACE STATION: BACKGROUND AND CURRENT STATUS

Daniel V. Jacobs
Manager, Russian Integration, International Partners Office
Space Station Program, NASA
Houston, Texas

Abstract

The International Space Station, as the largest international civil program in history, features unprecedented technical, cost, scheduling, managerial, and international complexity. A number of major milestones have been accomplished to date, including the construction of major elements of flight hardware, the development of operations and sustaining engineering centers, astronaut training, and several Space Shuttle/Mir docking missions. Negotiations with all International Parters on initial terms and conditions and Memoranda of Understanding (MOU) have been largely completed, and discussions on bartering arrangements for services and new hardware are ongoing. When the International Space Station is successfully completed, it will pave the way for even bigger, more far-reaching, and more inspiring cooperative achievements in the future.

Introduction

The International Space Station Program is the largest scientific cooperative program in history. It draws on the resources and expertise of 14 nations: the United States, Canada, Italy, Belgium, the Netherlands, Denmark, Norway, France, Spain, Germany, Sweden, Switzerland, Japan, and Russia. The development, integration and operation of the contributions of each partner into a single integrated Station, with all of its associated supporting systems, facilities, and personnel, is perhaps the most complicated and difficult international peacetime effort ever undertaken, partly because the entire Space Station will be assembled and tested for the first time in orbit, without the benefit of ground assembly and checkout. The critical factors in meeting this challenge are the dedication of the individuals and teams involved in all the nations who are participating and the relationships they have formed with each other.

Background

The current International Space Station (ISS) was born from the Space Station Freedom Program. In his State of the Union Message to Congress in January 1984, President Ronald Reagan officially established the goal of developing a permanently inhabited station in orbit, later labeled Space Station Freedom. Invitations were issued to Canada, Europe and Japan to join in this effort and agreements with the Canadian Space Agency (CSA) and the European Space Agency (ESA) were reached in September 1988, and with the Government of Japan (GOJ) in March 1989.

However, in response to additional budget constraints, complaints about an unwieldy management structure, and concerns about the ability of the program to meet schedule milestones, the Clinton administration and NASA Administrator Dan Goldin called for a redesign of the station in the Spring and Summer of 1993. This became the International Space Station Alpha (ISSA), which remains the basis for our efforts today.

NASA reached agreement with the Clinton Administration and with Congress that the ISSA would be implemented with a flat budget of $2.1 billion per year, for a total of $17.4 billion. In exchange, the Administration and Congress would not again be required to redesign and rescope the station. In order to accomplish these goals, NASA formed a new Space Station Program Office, located at the Johnson Space Center.

Russian Involvement

During the Crystal City redesign effort, an expanded relationship between the U.S. and the newly-formed Russian Republic was evolving in ways that would have dramatic impacts on the ISSA still under formation. A major objective of the administration was to keep Russian scientists and engineers involved in constructive activities and to prevent the transfer of missile and nuclear technology to other countries. Along with several other initiatives to accomplish this, the administration decided to expand the scope of the Human Space Flight Agreement already in place.

In September 1993, Vice-President Gore and Prime Minister Chernomyrdin issued a joint statement calling for further expansion of the human space flight cooperation between the U.S. and Russia. The activities would take place in three phases.

The Phase One Program greatly expanded the activities under the 1992 Agreement, and dealt primarily with continued Shuttle flights to the Russian space station Mir and long-duration astronaut stays on Mir.

The second and third phases culminate in the construction of an international space station involving the U.S., its current partners, and Russia. The joint statement called upon NASA and RSA to produce by November 1, 1993, a detailed program implementation plan (PIP) of activities for all three phases. This effort entailed the merging of two distinct stations, the U.S. ISSA and the Russian Mir 2. Components of both would have to be integrated and assembled, piece by piece, so that the total station could be operated and maintained as a single vehicle, not only when completed, but also at each point during assembly. The station would also be served by two transportation systems now, and would operate at a new orbital inclination for the U.S. 51.6 degrees.

Upon completion of the PIP, NASA consulted with its Space Station Partners on its intentions to add Russia to the Partnership. The current Partners endorsed the proposal and a joint formal invitation was issued to the Government of Russia on December 6, 1993.

Concurrently with the development of the new PIP, an amendment or protocol to the 1992 Agreement was negotiated between NASA and RSA to cover the expanded Phase One activities, including cosmonaut flights on the Shuttle, up to two years astronaut stay time onboard Mir, up to ten Shuttle/Mir docking missions, and a joint science and technology program.

The Protocol mentioned reimbursable financial arrangements between NASA and RSA to cover the costs of the expanded Phase One and selected Phase Two activities, at a rate of $100 million per year, $400 million total. A $400 million Letter Contract was signed in December, 1993.

By June 1994, NASA and RSA had also developed an Interim Agreement for Russian involvement in the ISS. The Interim Agreement allowed Russia to begin work with NASA and the other Partners on the development of the ISSA while negotiations were ongoing for a formal Memorandum of Understanding that would make Russia an official Space Station Partner.

ISS International Partner Cooperation

MOU and IGA Negotiations

NASA and RSA reached an *ad referendum* agreement on a Memorandum of Understanding (MOU) between NASA and RSA in July 1996, following the signing of a NASA/RSA agreement in June on the sharing of ISS accommodations, resources, responsibilities and costs. This agreement resolved many outstanding technical and managerial issues, such as the sharing of common operations costs, utilization rights on board the ISS, crew makeup, and provision of logistics and other services.

The International Partners reached *ad referendum* agreement on the multilateral Intergovernmental Agreement (IGA) between their governments in December 1996. Having reached agreement on the IGA and the MOU with RSA, NASA is now in a position to update the MOUs with the other Partners and those negotiations are in an advanced stage.

The modifications to the existing MOUs and IGA with the existing Partners will reflect: 1) the new Partnership roles and responsibilities with Russia as a Partner, and 2) the evolving contributions of the existing Partners. The major issues discussed during these negotiations were:

- the transition from “Shuttle only” support of the ISS to a mixed fleet to include Russian, European and Japanese vehicles
- program management structures and U.S. lead management/integration role
- new Partner contributions and responsibilities
- a system for allocation of Station accommodations, resources and crew flight opportunities, in proportion to the common operations requirements that each partner provides or funds.
- sharing of common operations costs and methods of meeting obligations without exchange of funds
- integrated operations and utilization, including integrated crew concept

The goal is to sign a revised IGA with all Partners, an original MOU with Russia and revised MOUs with the existing Partners at the same time, so that all ISS Partners can move forward in a consistent and complementary manner.

Canadian Space Agency

Canada’s contribution to the ISS is the Mobile Servicing System (MSS) and its associate ground elements. The MSS will provide a second-generation robotic arm similar to the Canadarm developed for the Shuttle, and consists of the 58-foot long Space Station Remote Manipulator System (SSRMS) that can handle masses up to 220,000 pounds, a Base System, and a 12-foot robotic arm called the Special Purpose Dexterous Manipulator (SPDM) that attaches to the SSRMS.

CSA will also develop a Space Operations Support Center, MSS Simulation Facility and Canadian MSS Training Facility. The first consules of the Operations Support Center have already been installed and were used to monitor operations during the STS-74 Shuttle mission to Mir in November 1995, which included the flight of a Canadian mission specialist and Canadian experiments. One such experiment was the Canadian Space Vision System, an advanced camera system that will be used to assist astronauts as they manipulate the SSRMS during Station assembly. Also delivered to the Space Operations Support Centre in late 1996 was the MSS Operations and Training Simulator.

In response to federal government fiscal pressures in 1994 similar to those faced in the United States, CSA experienced budgetary cuts and informed NASA that the Canadian contribution needed to be restructured. In May 1994, NASA and CSA signed the "Arrangements for Enhanced Cooperation in Space." The Arrangements refined NASA/CSA cooperation in a broad spectrum of areas. NASA agreed to take on responsibility for tasks costing approximately $100 million (U.S.); consequently, CSA's Space Station utilization allocation was decreased from 3.0% to 2.7%, or 2.3% if Canada does not develop the SPDM.

Negotiations between NASA and CSA are in the final stages to determine if the arrangements agreed to in 1994 can altered again so that various elements of the SSRMS could serve as offsets to CSA's common system operating costs, thereby reducing Canada's cost of utilizing ISS. A decision by the Canadian Government concerning budget authority and contracts for the SPDM should be made in January 1997. Although NASA expects this decision to be positive, if CSA does not pursue a SPDM program, NASA is prepared to provide an alternative system.

National Space Development Agency of Japan

The Japanese contribution to the ISS has remained stable and unchanged since the original MOU was signed between NASA and the GOJ. The National Space Development Agency of Japan (NASDA) will provide the Japanese Experiment Module (JEM), which consists of a number of different components, including the following elements:

- Pressurized Module (PM) - pressurized laboratory, providing 77% of the utilization capability of the U.S. laboratory and can accommodate 10 racks
- Exposed Facility (EF) - external platform for up to 10 unpressurized experiments
- Remote Manipulator System - 32-foot robotic arm used for servicing system components on EF and changing out attached payloads
- Experiment Logistic Module (ELM) - carriers for both pressurized and unpressurized logistics resupply

All of the JEM elements are scheduled for launch on the Space Shuttle. The delivery of the JEM elements to the ISS will commence in June 2000 with the launch of the JEM ELM-PS on a shared flight that also contains U.S. elements. In November 2000, the JEM PM will be the primary payload for one Shuttle mission. Subsequent shared flights in May 2001 and November 2001 will deliver remaining JEM components to orbit: the JEM EF, ELM-ES and JEM racks.

The Japanese completed a feasibility study of the H-II Transfer Vehicle in March 1995 and requested that NASA include the use of the NASDA Logistics System in the ISS baseline for logistics resupply. It consists of the H-II Transfer Vehicle (HTV), the H-IIA launch vehicle and the ground segment. The Japanese have also proposed use of their planned Data Relay and Tracking satellite for complementary communication support to the ISS. NASA and NASDA are currently working together to explore the types of missions the HTV could perform.

The majority of the component and assembly engineering models have been manufactured. System integration of the engineering model is underway. Manufacturing of the proto-flight model components and assemblies have begun.

To support its participation in the ISS, NASDA has constructed and outfitted a number of facilities. In 1992, Japan began development of its own Weightless Environment Test System (WETS) and began facility operations in 1994. The WETS facility is outfitted with a simulation tank, control center, and extravehicular mobility unit support equipment, all of which will be used in NASDA's verification testing of the JEM. NASDA also constructed an astronaut training facility to support ISS crew selection and training, health care, and human space flight technology development. Finally, in July 1996, NASDA completed construction of its Space Station Operations Facility, which will be used for JEM operations. These facilities join the already completed Space Experiment Laboratory and Space Station test building to comprise the Space Station Integration and Promotion (SSIP) center at Tsukuba Space Center.

NASA and NASDA are currently in discussions about the potential provision of new elements by Japan as a partial offset to the costs for launching the JEM module on the Shuttle. The new elements being examined are a Centrifuge Accommodation Module (CAM), the centrifuge rotor motor, and an experiment glove box. A decision by the Japanese government is required by March 1997, prior to the next NASA/NASDA Joint Program Review scheduled for April.

European Space Agency

ESA formally committed to its current complement of contributions at the ESA Ministerial Meeting in Toulouse, France, October 1995, after several years of internal political and economic discussions. The approved contributions are:

- the Columbus Orbital Facility (COF, formerly the APM), with accommodations for 10 standard racks, 5 of which are allocated to European users. The COF provides 77% of the utilization capability of the U.S. laboratory. Development of the COF began in January 1996 and is scheduled to be launched in early 2003.
- the Automated Transfer Vehicle (ATV) for ISS logistics resupply, propellant resupply and reboost missions, to be launched by the Ariane 5 launch vehicle. An ATV demonstration flight is scheduled for March 2002 with the first flight of an ATV to the ISS in early 2003.
- Phase A/B studies for a crew transfer vehicle (CTV) that could be used for crew rotation. The studies will take place between 1996 and 1998, with a recommendation for pursuing full development put forth in late 1997.

In addition to this contribution to the ISS partnership, ESA will receive early utilization access to the ISS and two astronaut opportunities prior to the launch of the COF in exchange for ESA provision of capabilities to support early utilization functions and ground facilities. Specifically, ESA will provide a microgravity glovebox, an 80 degree freezer, a scientific instrument pointing system, and ground software to support the Mission Build Facility.

ESA has also made separate arrangement with the Russian Space Agency for 2 contributions to the Russian elements: the European Robotic Arm (ERA) on the Russian Science and Power Platform and the Data Management System (DMSR) for the Service Module.

NASA and ESA are currently discussing potential bartering arrangements to at least partially offset the costs of the launch of the COF on the Shuttle. NASA and ESA also initiated joint studies in March 1996 to determine the feasibility of developing a common core for the US Crew Return Vehicle (CRV) that would be shared by the ESA Crew Transport Vehcile (CTV). Definition and analysis of this common core concept will continue through the end of 1997, when a final decision will be made on the implementation of the common core and NASA/ ESA cooperation.

Italian Space Agency

In 1991, NASA and the Italian Space Agency (ASI) entered into an agreement whereby Italy would develop two Mini Pressurized Logistics Modules (MPLMs) in addition to being a member of ESA. NASA would use the MPLMs to fulfill its responsibility to provide the ISS pressurized logistics capability. In exchange for providing the MPLMs, ASI receives a portion of NASA's ISS utilization capability.

Following the Crystal City redesign effort, NASA and ASI decided to amend and renegotiate certain aspects of the agreement to reflect changes in requirements and to add a third MPLM. In addition to providing the modules, ASI will develop a sustaining engineering center, the MPLM Technical Center, in Turin, Italy. The Center will be used to receive data from the modules and to control Italian utilization experiments on ISS.

As a member of ESA, Italy will also provide the structure for ESA's COF module, using the same module design as the MPLMs. In return, Italy will use the European life support system, or ECLSS, developed for the COF as the ECLSS system aboard the MPLM.

The first MPLM unit is scheduled to be delivered to Kennedy Space Center in March 1998 and launched in December of the same year. The second unit will be delivered mid 1998 and launched in February 1999. The third unit will arrive at KSC in October 1999 and be launched in mid 2000.

NASA and ASI are currently negotiating the potential provision of two Nodes by ASI. One node would serve as Node 2 on the Station, in place of the Node Structural Test Article currently under construction by Boeing. In exchange for the Nodes, ASI would receive additional utilization rights onboard Station, as well as Government Furnished Equipment (components/boxes to be integrated into the Nodes). A decision is due by the end of January.

Russian Space Agency

The currently-planned Russian contributions to the ISS include: service module, universal docking module, science power platform, docking compartment, life support module, and research modules. This is approximately a third of the mass of the completed assembly of the ISS and will provide nearly half of the pressurized volume of the ISS. The service module will provide early sleeping and living quarters for crew members. Russia will also provide logistics resupply and station reboosting capability with the Progress and other vehicles, as well as crew transfers aboard the Soyuz vehicle.

NASA is also obtaining the Functional Energy Block, or FGB, module from Khrunichev, a Russian company, under a contractual arrangement. Because this capability was a NASA requirement, NASA is procuring the FGB for $190M and providing it as a U.S. contribution.

RSA approached NASA in December 1995 with a proposal to consider utilizing the existing Russian Mir space station during the early assembly stages of the ISS. RSA said that Mir would last longer than originally projected and that it would be difficult to explain to the Russian government and the Duma why a Russian national resource would be "abandoned" to join an international, U.S.-led effort. RSA also explained that some Russian contributions to the ISS were underfunded and would perhaps not be available.

After difficult and detailed discussions in December 1995 and January 1996, NASA and RSA agreed to extend NASA's use of Mir by augmenting the Phase 1 Program and to modify some Russian contributions to the ISS. For example, the science power platform will now be launched aboard the Shuttle, not a Proton, and Progress logistics flights may be provided by a new FGB-based logistics cargo vehicle (LTV) instead. RSA also recommitted to providing the FGB and Service module as designed on schedule. These arrangements were confirmed at the Gore/Chernomyrdin Commission meetings in Washington in January and again in Moscow in July 1996.

Another important milestone was reached in June 1996 when the agreement on the balance of contributions of goods and services, and the resulting cost implications discussed above was signed.

In the Fall of 1996, RSA formally informed NASA that sufficient funding had not been received from the Russian Government to support the development of the Service Module (SM) and follow-on elements and that the SM would be at least 8 months late. NASA and Russian space organizations held a number of meetings in November and December of 1996 and January 1997 to discuss methods for accommodating the delay of the SM and other changes. During this time, the Russian Government finally approved the budget for RSA for 1997 to support their continuing work for ISS and to meet the new schedules. A Joint Program Review was held in Moscow on January 24, 1997 to finalize and confirm these arrangements.

<u>Brazilian Space Agency</u>

NASA has engaged in discussions with the Brazilian Space Agency (AEB) about the possibility of Brazil joining the Space Station international team. Discussions have included the provision of various components or hardware for the Station, in exchange for utilization rights. No decision has been made by either side yet, but discussions are continuing.

U.S. Contributions

The U.S. is the initiator, integrator, and leader of the International Space Station Program. The U.S. hardware contributions begin at the start of the assembly phase with the first launch — the FGB control module mentioned above. The FGB provides initial propulsion, propellant storage, attitude control, and data links for the station. Other U.S. hardware added to the station in Phase II includes:

Node 1, linking the FGB to the U.S. Lab Module
Pressurized Mating Adapters
U.S. Laboratory Module with 3812 cubic feet of volume and 13 Integrated Standard Payload Racks
Truss segments Z1 and P6
A pair of large solar arrays for generating a total of about 19 kilowatts of electrical power
Airlock for spacewalks using Russian and U.S. space suits

U.S. hardware contributions in the station's completion phase include:
Node 2, linking the Lab to the Centrifuge, the JEM, and Europe's Columbus Orbital Facility (COF) modules
Habitation Module, providing living quarters for U.S. and international crew members
Centrifuge Module, a unique biomedical space laboratory providing artificial gravity
Cupola for viewing robotic operations used in assembling and maintaining the Station
Remaining segments of the 310-ft-long truss
Three additional pairs of large solar arrays

At the end of the assembly phase in 2002, the U.S. segment will provide almost half of the station's pressurized volume.
By Assembly Complete in 2002, the U.S. will provide integrated ISS services for all the international partners, including:
Electrical power generation, storage, and distribution
Communications
Data storage and distribution
Thermal control
Environmental control and life support
Crew health maintenance
Attitude control using control moment gyroscopes
All power for the U.S., Japanese, and European modules (about 88 kilowatts) will be generated by four pairs of large, truss-mounted U.S. solar arrays and will be routed through U.S. power storage and conditioning systems. The U.S. communications contribution will include the U. S. Space Flight Tracking and Data Network on the ground and the Tracking and Data Relay Satellite System in space.

The Mission Control Center (MCC) at the Johnson Space Center in Houston, Texas, and the Payload Operations Integration Center (POIC) at the Marshall Space Flight Center in Huntsville, Alabama, provide integrated station mission and payload control. The partners will operate Payload Operations Control Centers in their own countries, which will be "networked" into the integrated research operations of the International Space Station.

The U.S. also provides the Space Shuttle, a vital transportation link for station assembly and operations. In addition to U.S. station components and astronauts, the Shuttle will deliver hardware and ferry crew members and their supplies for all the other international partners. The Shuttle is also the only spacecraft in the world capable of returning to Earth large quantities of equipment and experiment results.

Because of the delay of the Russian SM discussed above, NASA is currently considering the development of additional modules to provide additional reboost and propulsion capabilities and redundancy. They may include an early Interim Control Module, to ensure the continued operation and assembly of the Station in the case of a late SM, and a later Propulsion Module, to provide reboost and refueling capability from the Shuttle downstream.

Benefits of Changes

The changes in the ISS Program since the redesign effort in 1993 have provided significant benefits for NASA and our International Partners. Rather than a single route to the ISS, there is now multiple access to the Station, including the U.S. Shuttle, the Russian Soyuz and Progress vehicles, the Ariane Transfer Vehicle, and H-II Transfer Vehicle. Distributed operations and utilization control centers are now possible. Canada will establish an MSS Control Center in Saint Hubert near Montreal. Europe and Japan will establish centers to operate and receive data from their experiment payloads aboard the Station. Russia will of course operate TsUP, or Mission Control Center, in Moscow to support the Russian elements aboard the Station and their transportation vehicles, and to serve as backup Station Mission Control.

The addition of the Russian space program to the Space Station partnership has also enabled:

- Larger volumes onboard the Station
- Larger crews
- Earlier permanent habitation
- Greater science capability earlier
- Automatic docking systems for use of unmanned supply vehicles
- Greater exposure to earth's surface, through a higher inclination orbit, to increase earth observation capabilities
- Use of proven technologies to decrease development and testing costs

Accomplishments

Management

Early in 1996, NASA reorganized the way that NASA Headquarters worked with the NASA centers. It was decided that for each of NASA's major enterprises or programs, a single lead center would become the focal point for each enterprise. NASA announced in February 1996 that Johnson Space Center (JSC) would become the lead center for the NASA Space Station Program, and the program management would be centralized at JSC. The Program Manager, already physically located at JSC, would report to the Center Director. The Program Director at NASA Headquarters would maintain a small staff and will be responsible for relations with Congress and external organizations.

Deputy Program Managers were also named in the areas of Operations, Business, and Technical Development to focus attention on these critical areas. Single team leads were identified for all integrated product teams to clarify roles and responsibilities. This was part of the Program's transition toward a more traditional prime contractor/NASA customer relationship than was present early in the program.

In addition, greater involvement from Marshall Space Flight Center, Kennedy Space Center (KSC), and other directorates in Johnson Space Center was achieved. A Hardware Integration Office has been established at KSC to manage and integrate the ground processes for the U.S. elements. Monthly Station Development and Operations Management meetings have been established to provide management focus and quick resolution of issues and areas of concern.

Technical

In March 1996, the second Incremental Design Review (IDR) was completed, to ensure that the design of all elements, systems and subsystems included in the increment has been completed, as well as all actions and open items associated with that increment. A follow-on to the second IDR, or IDR 2B, was held in September for the purpose of reviewing and recommending approval of a revised ISS assembly sequence caused by the Russian changes that were discussed above.

During 1996, an Independent Assessment Review was also conducted of the program. A number of suggestions were made to improve the program and several have already been implemented. Significant improvement has also been made in several programmatic processes, such as configuration management, risk management, and management information systems.

In addition, the previously-discussed meetings with the Russians were held in November and December 1996 and January 1997 to address problems caused by the delay of the Russian SM. Various options for working around the SM delay while continuing with the assembly of the Station were developed.

Hardware

Over 130,000 pounds of U.S. flight hardware had been manufactured by the end of the third quarter of 1996, more than 30,000 pounds above projections at that point. During the summer of 1996, significant problems arose during pressure testing of Node 1. Node 1 finally passed its pressure testing late in August. Using multiple shifts, the delay will be made up and Node 1 should launch on schedule in December 1997.

However, the main challenge is yet to come. Scheduled hardware completions in 1998 jump to 223,200 pounds, from 70,100 pounds in 1997. Even with the improvements made thus far, extreme diligence, continuous improvement, and dedication will be required to meet this goal.

Phase One Accomplishments

A number of historic and dramatic Phase One events have been accomplished to date. Beginning with the STS-63 close rendezvous mission in February 1995,through Dr. Norman Thagard's mission on Mir as the first NASA astronaut aboard a foreign launch vehicle, to the first Shuttle/Mir docking mission in July 1995, through 3 more docking missions, the record-setting flight of Shannon Lucid in the summer of 1996, the flight of John Blaha, and finally with the current mission of Jerry Linenger, and including all the support activities like the development and launch of the Docking Module, the exchange of Russian crews, and the transport of logistics materials, the Phase 1 Program has been a huge success.

Specific lessons learned and experiences gained during Phase One that will benefit the Space Station include:

- Russian-developed docking system was validated.
- Space Station Shuttle approaches were developed and flight tested.
- Rendezvous and docking investigations performed.
- Risk Mitigation experiments performed.
- Shuttle's capability to control the attitude of large structures was validated.
- Methods for exchanging data between mission control centers.
- Shuttle's ability to transfer and resupply logistics material to a station.

Conclusion

The ISS Program continues to face significant challenges. We must live within our budgetary constraints, overcome cultural and national differences, build and operate the ISS on schedule, and maintain a global interest, excitement, and commitment to the Program.

This widespread program will produce hardware in different countries, operate various control centers, provide multinational crews, and all the other work that goes into producing a Space Station. When this is all integrated into a single functional, productive and inspirational entity, the International Space Station, it will be recognized as a historical accomplishment and will serve as a tribute to the experienced and capable workforce who produced it.

SPACE CONGRESS 1997
April 30, 1997

THE INTERNATIONAL SPACE STATION:
BACKGROUND AND CURRENT STATUS

Dan Jacobs
Manager, Russian Integration
International Partners Office
Space Station Program
Johnson Space Center, NASA