S/M Congress Hearing Mir

Hearing on the Mir Safety
September 18, 1997
before the
Committee on Science
House of Representatives

HEARING SUMMARY:

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MEMORANDUM FOR THE RECORD

SUBJECT: House Science Committee Hearing on "Mir Safety": Sept. 18, 1997

Testifying: Captain Frank Culbertson, Program Director, Phase One Roberta Gross, NASA Inspector General James Oberg, Russian Space consultant Marcia Smith, Russian Space expert, Congressional Research Service

Chairman James Sensenbrenner (R-WI) held a 4-hour hearing of the House Science Committee on Thursday, September 18 on the status of Phase One of the International Space Station, the Shuttle/Mir Program. Due to the high profile nature of the subject, the hearing was very well attended, with 24 of the committee members participating, as well as live coverage by C-SPAN, with overflow audience in a separate conference room.

In his opening statement, Chairman Sensenbrenner referred to the Challenger tragedy, and labeled the recent "mishaps, excuses, inconsistencies" on the Mir as "Mir-haps." He promised to hold hearings in the future that would allow General Tom Stafford, who was unavailable for this hearing, and all the astronauts who had lived aboard Mir, to testify on their experiences. He challenged the Russian government to provide their part of the International Space Station and to repair shortfalls, rather than disgracing their own cosmonauts. He asked the Committee to keep in mind that Captain Culbertson was not responsible for the grand decisions of NASA’s space program.

Ranking Minority Member George Brown (D-CA) stated that he agreed with the Chairman’s diligence in pursuing oversight of the Shuttle/Mir program, but felt it wasn’t appropriate for the Committee to insert itself into the 3-prong safety review process already in place, which was based on careful analysis, not anecdotes. He said that the Committee can’t be NASA’s safety engineers and shouldn’t be involved in operational details, but rather should have a broader perspective. He felt the program had been enormously successful so far, and that NASA and the Committee should remain vigilant.

Testimony began with NASA's Inspector General, Roberta Gross, who discussed her interim report reviewing NASA's safety inspection for Phase One, focusing her attention on the recent Mir mishaps and questioning the impartiality of the independent commission to review safety standards, led by former astronaut General Tom Stafford, and the "system of checks and balances" in place at Johnson Space Center. Her testimony was followed by a request by Congressman Ralph Hall (D-TX) that the Inspector General's testimony not be included in the record until General Stafford was available to testify in his own defense. Chairman Sensenbrenner denied the request, stating that the record on the Shuttle/Mir program would not close until all hearings on the subject had been held. Captain Frank Culbertson, Director of Phase One, testifying on behalf of NASA, reported that he had participated in the Flight Readiness Review meeting on September 12, which included the Russians, and that he believed that both the shuttle and Mir satisfactorily met safety standards, and approved launch of STS-86 on September 25. During his testimony on reports of Mir spinning wildly out of control when the computer system had been down, he approached a model of Mir, saying, "This is what the Mir looks like when it is rotating. I believe that even the most squeamish of roller coaster riders would have no problem dealing with this." Jim Oberg testified as an individual without affiliation, based on his experience with Russia and the space program, and questioned the continuation of the U.S. presence on Mir, claiming that Mir should be left in the past and focus should shift to the International Space Station. He stated that when NASA canceled its participation in the Bion-12 primate experiment, there were no accusations of being "sunshine explorers," a term Culbertson's Russian counterpart, Valery Ryumin, used in the STS-86 press conference on Wednesday to describe the Americans if they were to pull out of the Shuttle/Mir program at the first sign of trouble. Astronauts should be treated at least as well as primates, Oberg claimed. Finally, Marcia Smith of the bipartisan Congressional Research Service testified that the conditions on Mir do not seem to be as bleak as reflected by the media and that careful analysis by NASA is in place. She closed her testimony, however, by quoting astronaut Dr. Jerry Linenger as saying that participation aboard Mir had become a matter of "survival for survival's sake."

Chairman Sensenbrenner began the questioning with a series of questions about the anomalies of the O-rings in the Challenger that had caused the accident, and citing an increase in the number of Mir failures in the past year. He also quoted Associate Administrator Fred Gregory as stating that NASA did not have safety standards in place for the Shuttle/Mir program. Culbertson responded that there is a difference between safety standards and a certification of standards, which is what Mr. Gregory had been describing. Congressman Brown's questions focused on bringing perspective to the situation, due to the risk inherent in all human space flight. He asked about the failure of the soft landing engine of the Soyuz on its return with Commander Tsiblyev and Mission Specialist Lazutkin, to which Culbertson responded that after careful analysis it had been ascertained that if someone had been sitting in the empty seat in the Soyuz, he would not have been harmed, as had originally been reported.

Vice Chairman Dr. David Weldon (R-FL) asked about the science that can be done aboard Mir if the crew is "constantly doing operational repairs." Culbertson informed him that repairs are not constantly being done and that 550 hours are allotted for research programs for David Wolf's increment aboard Mir. Congressman Tim Roemer (D-IN) stated that it was not his intention to be critical of NASA or its staff, but rather to exercise critical analysis in the Committee's jurisdiction over NASA. He asked Jim Oberg if he believed the Shuttle/Mir program should be suspended, and Oberg said "yes." He then asked the Inspector General when her report would be finished, but she did not give a specific date. A follow-on hearing after completion of the report was promised.

Other questions focused on the fire that had occurred on Mir in February, the collision in June, and the procedures in place to assure safety for our astronauts. Although Dr. Shannon Lucid, who lived aboard Mir longer than any other American, and Col. Charles Precourt, a shuttle pilot who has been aboard Mir twice, were in attendance with Capt. Culbertson, Chairman Sensenbrenner would not permit them to respond to questions addressed to Capt. Culbertson about statements attributed to her about the carbon dioxide scrubber, and to Soyuz pilot training that he had received. Chairman Sensenbrenner assured the Committee that there would be future hearings to allow all the astronauts who had lived aboard Mir and General Stafford to testify on the subject. Captain Culbertson was asked if he would be willing to go to Mir, to which he responded, "I would love to go now, and I think my wife would let me." Mrs. Culbertson, who was seated behind her husband, nodded her approval. When the Inspector General was asked why she would not name or even indicate the number of anonymous NASA employees whom she claimed to have interviewed for her report, she stated that the Inspector General's office provided confidentiality to all employees, and that those who requested confidentiality feared for their jobs at Johnson Space Center. Space and Aeronautics Subcommittee Chairman Dana Rohrabacher (R-CA) stated that "(t)he Administration is trying to paint the best picture…." He questioned Oberg about the financial situation of the Russians, suggesting that they are financially unable to meet safety standards, although senior management is building brick mansions in Star City. He asked that Culbertson's letter to Ryumin asking why the Altair satellite wasn't employed for communication during the fire episode aboard Mir be placed in the record, as well as Ryumin's response.

A sharp warning to NASA and the Administration was delivered by Congressman Curt Weldon (R-PA) about the technology transfer by the Russians to Iran of the gyroscopes, which he claimed was a direct violation of the Missile Technology Control Regime (MTCR), declaring that "this program is going to go away."

In a statement released after the hearing, Congressman George Brown indicated that he was "unwilling to conclude on the basis of the evidence presented at today's hearing that Mir is unsafe for occupation by American astronauts." However, Chairman Sensenbrenner stated in a press conference that "(t)here has been sufficient evidence put before this hearing to raise doubts about the safety of continued American long-term presence on the Mir."

Statement of Capt. Frank Culbertson (USN-Ret)
Phase 1 Program Manager
before the
Committee on Science
U.S. House of Representatives
September 18, 1997

Mr. Chairman,

I am here today to discuss the status and future plans for the Phase 1 Program, commonly referred to as the Shuttle/Mir Program. This hearing, of course, comes at a time when we are making final preparations to launch STS-86 on September 25th--the next mission to rendezvous and dock with the Russian Mir Space Station and begin the sixth long-duration stay of a US Astronaut aboard Mir. The basis for the decision to proceed with that flight is of obvious interest to the Committee, and I will address that issue in detail.

I believe strongly that we must directly and thoroughly address the circumstances and implications of recent problems aboard Mir, and whether or not they impact the safety of the crew aboard Mir. At the same time, any discussion about those problems must include a review of the impressive record of our highly successful experience aboard Mir through the Phase 1 Program. Let me first address the issue I believe to be of the greatest concern to the Committee: the question of the process used to make the decision to continue the Phase 1 Program.

Phase 1/Shuttle/Mir Safety Assurance Process

The safety of the men and women who are or will be asked to journey into the harsh environment of space is the primary consideration that must underlie and drive all other questions of mission, value and purpose in the nation’s space program.

The Phase 1 Program has relied on a number of different systems and processes to identify and assess the expected risks and the readiness to proceed with the next Shuttle/Mir mission and/or the next Long Duration Mission increment. These processes include an assessment of Russian Segment safety standards, hazard analyses, real-time operations assessments, Major Mir Systems Requirements agreements, Certification of Flight Readiness Statements, and Flight Readiness Reviews.

Several years ago, the International Space Station Program conducted a detailed review of Russian design specifications to gain a better understanding of the overall Russian engineering design process. As a part of this effort, over 265 documents and specifications were reviewed over a 2-year period. This assessment, which included two major technical interchange meetings and over 200 teleconferences, was intended to assure the safety and interoperability of the

Russian segment with the rest of the International Space Station. Each standard was addressed individually and then reviewed through management. In order to complete this review efficiently and in a reasonable period of time, the study assessed "equivalence to" rather than "compliance with" U.S. requirements. This was felt to be a reasonable approach since the Russians already had an established history of safe and successful flight operations, and the Russian hardware design was mature. In addition, the Russian hardware approach is very similar to the U.S. approach, requiring 2-fault tolerance for crew safety and 1-fault tolerance for station safety. The results of this study showed that most standards were comparable and acceptable. Comparable standards included structures and fracture control, electrical grounding and electromagnetic interference, materials off-gassing and toxicology, and environments. A few issues were identified, but they were not considered critical for Phase 1. Although the study was aimed at evaluating hardware to be developed for the International Space Station, the results provided an additional measure of confidence in understanding the pedigree of hardware manufactured for the Phase 1 Program, since the same basic organizational structure and design guidelines were used in each case.

Since the beginning of the Program, a very thorough hazard analysis and documentation system has been used. Each side establishes safety requirements to be met by the other. Compliance with these safety requirements is then documented and approved. Joint provisions are developed to respond to any off-nominal situations which can reasonably be anticipated. Any recent anomalies by either side are documented and explained. Thus, NASA provides details on the circumstances and resolution of problems experienced on the Shuttle, while the Russians do the same for problems on the Mir. This process has been extremely helpful in understanding hardware failure histories and in building a level of trust between the technical experts on each side.

An excellent way to obtain first-hand knowledge on the safety and readiness of the Mir is to participate in real-time operations. NASA has been able to do this by having U.S. flight controllers work in the Russian Mission Control Center (TsUP). In addition, technical and scientific support is provided at the Payload Operations and Support Area (POSA) in Houston. When EVA's or other special activities are planned, NASA normally sends Flight Directors and other technical experts to Moscow to participate in the planning and conduct of the event.

Some of the most important factors in determining the readiness of the Mir to support continued operations are the status of major systems onboard and the supply of consumables available. Prior to STS-84, a list of specific requirements was developed relating to the environment and major system status. This document, entitled "Major Mir System Requirements to Allow Mission of U.S. Astronaut to Continue," includes safety responsibilities, nominal atmospheric conditions, primary and backup system requirements, and criteria for early return of the crew. Both sides have agreed to abide by this document, which provides clear-cut quantitative guidelines for measuring overall system health.

Several weeks prior to the start of a new increment, each Phase 1 Joint Working Group performs an assessment of their readiness to proceed. To ensure that specific standards have been followed and that the responsible parties are held accountable, Certification of Flight Readiness statements are then prepared to record the results of these assessments. A top-level readiness statement is also completed by the U.S. and Russian Phase 1 Program Managers.

Prior to committing to flight, several reviews are conducted for senior management. First, a Phase 1 Flight Readiness Review is held, involving just U.S. participants. Next, a Joint Flight Readiness Review is conducted, including both U.S. and Russian management officials. At each meeting, technical experts present the status of their area of responsibility, any issues or concerns that they are aware of, and any open work. The Chairman and other members of the board listen to the presentations, ask questions, and assign actions as required to follow up on any remaining problems or issues. These reviews are in support of a final assessment of the mission at the Shuttle Flight Readiness Review, approximately 2 weeks prior to launch. It is at this review that a final approval is given to proceed with launch preparations. Any changes in the readiness status of the Shuttle or the Mir can still be addressed by the Mission Management Team, either at the L-2 Day Review, or during the Shuttle Countdown itself.

In addition to the internal and joint review processes, the Stafford Committee, chaired by General Tom Stafford, has conducted an independent review of the readiness for each Shuttle/Mir mission. In view of the recent series of incidents aboard Mir, General Stafford appointed a "Red Team" from among members of the Committee to focus in-depth on the issues relating to the Mir’s readiness to support the next mission. The Stafford Committee report, including the special "Red Team" report, will be provided to the NASA Administrator next week, and available for review before the launch-minus-two day briefing to be held on the 23rd.

The Extraordinary Value of Phase 1

What is now known as the Phase 1 Program grew out of an initial plan to exchange crew members with Russia aboard the Mir Space Station and the US Space Shuttle. That represented a very significant commitment of the two countries to work together and especially to trust one another. Detailed information would be exchanged on many subjects that were considered sensitive by both sides. The US was concerned about intellectual property rights and the unprotected transfer of technology to the Russians. The Russians were concerned about giving access to sensitive facilities and information critical to their national security. Seen in this light, the accomplishments of the Phase 1 Program to date are extraordinarily impressive and go far beyond anything imagined when the notion of US-Russian space cooperation in crew exchanges was first considered.

The Phase 1 Program is the precursor to the International Space Station. Its four primary goals are:

* Learn to work together with each other, both in space and in ground support activities.
* Reduce the risks to International Space Station development and operations by testing hardware, refining joint procedures and integrating the operational practices of the two nations with primary operational responsibility for the International Space Station.
* Gain experience in long-duration stays on a space station and develop effective bio-medical countermeasures to the effect of extended weightlessness.
* Conduct scientific and technological research in a long-duration environment, gaining both valuable research data and developing effective research procedures and equipment for use in the International Space Station.

The scope and activity of the Phase 1 Program has been increased from the initial notion of a modest crew exchange to include seven long duration astronaut visits aboard the Mir as well as a significant science program on board utilizing two tons of US science hardware integrated into the Mir, most in the Spektr and Priroda modules. Initially, the role of the US crew was patterned after that of the other foreign personnel to fly to the Mir as guest cosmonauts. Our overall involvement was as a customer who would conduct the science program and not be directly involved in the operation of the spacecraft itself. The majority of the early lessons learned had to do with life on a long duration mission, the logistics of supporting such a mission, the psychological factors involved, what it takes to conduct a long duration science mission, and the techniques the Russians use to manage their space station program, as seen by observing the Russian flight control team while not actually getting involved in the operations themselves.

As the Shuttle/Mir missions progressed, it became clear that our goal of learning how to work with the Russians should include direct knowledge of the operational techniques through involvement in the operations themselves. The Russians quickly agreed to the principle of making our astronauts an integral part of the crew, and work was begun to modify the training program to allow for expanded duties with some changes made even before Shannon Lucid's mission, including the role change from Cosmonaut Researcher to Flight Engineer-2. Final agreement on the new training program was reached in the summer of 1996 and the formal documents signed in August of 1996.

Mike Foale was the first US astronaut to see the full effect of this new program in his training. It is evident that Mike is considered a full part of the Mir crew and it is reported that he has gained high respect from both of his crew mates and the control team in the Russian control center. Since the Progress collision, Mike has participated in an external spacewalk (EVA), was accepted as the replacement secondary EVA crew member for the internal EVA, and would have performed that function had the decision been made to proceed with that EVA before the arrival of the next Mir crew. He has actively participated in the ongoing maintenance and restoration of Mir systems and is seen as the on-board computer expert. That role is being continued in the training and preparations for Dr. Wolf to join the crew during the next Shuttle flight.

In significant and important ways in the Phase 1 Program, we are now functioning in a partnership role with the Russians in the operation of a space station. This experience is invaluable in preparing us for our leadership role in the assembly and operation of the International Space Station, and the continued cooperation with our Russian partners in that important undertaking.

Phase 1 is Not Without Difficulties

In the past several months, as series of events have taken place aboard the Mir Space Station that have caused concerns about the continued safety and justification for the Shuttle/Mir missions. The following is a brief review of those incidents and what we currently understand about them.

The fire on Mir in February was serious and demanded a careful response. In particular, it required an assessment of the safety of the design of the oxygen generator used to back up the Elektron system as well as the operational response of the crew. Although review of the design and operational history of the oxygen generator resulted in its being cleared for continued use, the final report on the investigation into the causes of the fire was not available until recently, due to the time required to return the hardware from orbit to the manufacturer. The results of that investigation indicate that fire was most probably due to the absence of a rubber seal that can be inspected by the crew prior to operation. The design of the generator is sound, and appropriate operational precautions are in place to make the possibility of a repeat occurrence extremely remote. The operational responses of the crew to the fire were appropriate and demonstrated that the Russian training and procedures are adequate.

A second effect of the fire was an immediate improvement in the communications between the US and Russian technical and management teams. The delay in notifying the US regarding the fire has been widely reported and was immediately remedied. In addition, the Russian management team directed all levels of technical specialists to increase the volume and speed with which technical information is shared with the US. Coupled with an increased effort on the US's part to have technical personnel following Mir systems and consumables, this marked a significant improvement in NASA's understanding of routine flight management activities and the technical situations that drive them.

Ethylene Glycol (EG) leaks

Small leaks of ethylene glycol (EG) coolant solution into the Mir environment have been noted since at least Shannon Lucid's tenure on the station. At that time, they were minor leaks that reduced the effectiveness of the thermal control system and prevented drinking of the condensate until the leaks were fixed and the EG purged from the water supply.

During Jerry Linenger's mission, EG leaks became a significant environmental concern as a source of mucus membrane irritation to the crew and potentially a long term health threat.

Discussions with the medical community indicated that EG in the atmosphere would become an intolerable irritant long before it posed a long term health threat, confirming that having Dr. Linenger monitor the symptoms on the crew would be an acceptable indicator of gross concentrations. The crew was prohibited from drinking the condensate pending the addition of effective EG filters to the system, which was accomplished on STS-84. As a conservative measure, the crew did not drink the water until samples were brought down on the Soyuz in August and analyzed. That analysis showed the water to be totally free of EG and was cleared for unlimited consumption.

The EG leaks were primarily the result of dissimilar metal corrosion that required the right combination of time on orbit and increased condensation to manifest itself. Once detected and understood, the Russian team developed effective repair and cleanup techniques to correct the problem. Equally important, design changes were developed for the Russian modules to be flown as part of ISS to prevent this problem occurring there.

In order to be better able to assess and respond to leaks that might occur on Mir in the future, NASA also developed and flew up on STS-84 environmental monitoring hardware able to detect and measure critical concentrations of EG. The Russian operations and medical teams recognize the value of this hardware and have embraced its use on all subsequent missions. The clear implication is that a real-time operational issue is the best way to motivate people to get past minor differences and make real progress. This has contributed to further improving the working relationship and insight between the US and Russia.

Progress Collision

The collision of the Progress 234 vehicle with Mir during a manual docking test on June 25 was the most serious event to happen on the station since its launch. Damage to Spektr resulted in the rapid depressurization of the module and nearly the abandonment of the station via Soyuz. NASA was aware that the test was planned, as well as its high level objectives, but had not been given detailed insight into the test planning or execution. This was consistent with the agreements established at the beginning of the Phase 1 Program where RSA was held responsible for the safety of all activities on the Mir and NASA was responsible for Shuttle safety.

The results of the accident investigation are still being assembled into a final product, and detailed comments are inappropriate at this time. However, the independent analyses performed by Energia and a team of US experts have many conclusions in common that indicate that a conclusive determination of probable cause is possible and imminent. It is believed that the causes can be adequately addressed so as to make a reoccurrence of this accident extremely remote.

However, this investigation has illustrated that there are opportunities to combine the strengths of the Russian system and methodology with NASA's to result in a capability exceeding that of either individually. Specifically, the introduction of US experiment planning and trajectory modeling personnel into the Russian process can provide valuable experience to the US team while improving the product of the Russian flight control team.

This realization, coupled with management imperatives to be more directly involved in the development of and concurrence with critical operational plans for Mir, has resulted in an initiative to significantly increase the amount of US operations personnel involved in basic Mir operations. Whereas in the past NASA has only been responsible for and a direct participant in the planning and execution of the science timeline, in the future NASA expects to have increasing communications between specialists on critical dynamic operations such as rendezvous and docking and EVA's, as well as systems related activities such as management of life support and other critical systems and the consumables that support them.

Science Recovery

Following the Progress collision it was recognized that the science program planned for Long Duration Mission 6 would require significant modification. The greatest challenges lay in the availability of hardware to replace that lost in the Spektr, and the availability of electrical power to conduct meaningful science. One other challenge was that the time remaining before STS-86 would not allow a major realignment of the science program in terms of developing and preparing new hardware, procedures, training materials, etc.

Approximately two weeks following the collision the US members of the Mir Operations Working Group and Joint Science Working Group traveled to Russia to negotiate a new science plan and finalize the program for Long Duration Mission-6. A tremendous amount of work was accomplished in a few short weeks and a preliminary agreement was developed based on known resources for experiments, and with a modestly optimistic expectation for power recovery from Spektr. The plan took advantage of backup flight hardware for some units lost in Spektr, as well as some new experiments that had not yet flown. The final plan now includes 35 experiments for the increment--more than any other to date!

The successful internal EVA provided power that is expected to support the science plan. The larger power users will have to be scheduled to be operated during periods of additional available power, which is good practice for ISS on which the same techniques will have to be applied. Although the mix of science has changed from what was originally planned, the science value of the 6th long duration increment is expected to be approximately 80% of the original. This is an example of outstanding resourcefulness and cooperation that should serve as a model for joint science programs everywhere.

Crew Change

Following the Progress collision, the Russian team began an ambitious effort to plan the repair and repressurization of the Spektr module. This plan has evolved over time and has increased in detail and fidelity with each passing week. One element of the plan that has remained essentially constant is its dependence on a large amount of EVA activity to find the leaks and repair the module. A joint decision was made that it is highly desirable to have all three crew on the Mir be EVA capable in order to have backup crew and to spread the workload.

This became an issue because it was known that the prime US crew for Long Duration Mission 6 did not meet the minimum size requirement of the Orlan EVA suit. This limitation was known at the time of her selection as prime for this mission, but since at that time there was no EVA requirement it was no issue for her selection. In addition to the size constraint, since this crew also had no EVA training in the US, there would not be time to accomplish a full EVA training program prior to STS-86.

On that basis the decision was made to switch to the backup crew for Long Duration Mission 6. This individual, who was being trained as prime for Long Duration Mission 7 and backup Long Duration Mission 6, had already received significant US EVA training and could be trained in the Russian system in time for STS-86. He has received sufficient generic EVA training to be qualified for EVA backup or contingency operations if required. The biggest impact of the decision was that some of the science baseline data collection that was taken on the Long Duration Mission 6 prime in the May 97 time frame was not taken on the backup and was therefore lost. Schedule impacts to accommodate last minute Shuttle training have made it necessary to combine Baseline Data Collection for several of the investigations, ensuring at least one session is completed for each planned investigation.

Risk Assessment

The crucial questions for many is whether, after this series of events, it is now sufficiently safe and potentially productive for the US to continue to support the Phase 1 Program.

We are reminded by this history of occurrences that we must be ever watchful and mindful of the need to ensure crew safety. The following is an overview of the safety assurance process as an ongoing and crucial aspect of the all of NASA’s human space flight activities. Safety is our highest priority, and it will not be compromised.

The greatest risk faced by Phase 1 Program is the possibility that a member of the crew could be seriously injured or die on the Mir, or that the Shuttle could be damaged during joint operations. For these reasons, and with the understanding and joint agreement that each country has a mature space program with established record of safe operations for their own vehicles, the majority of the early Phase 1 safety work was expended on the joint (rendezvous and docked operations) phase.

Crew Safety

From the start of the Shuttle/Mir Program it was agreed that a formal safety hazard analysis would be performed jointly with the Russians for the joint Shuttle/Mir missions. This approach to risk management was founded on the agreed-to policy that NASA was responsible for the safety of Russian cosmonauts on Shuttle and Russian Space Agency was responsible for the safety of U. S. astronauts on Mir.

Joint Shuttle/Mir safety analysis is performed for the approach, docked, and undocking mission phases. This joint safety process documents the safety assessment results for each mission, along with a set of requirements, compliance to those requirements, and documentation for flight readiness. All NASA hardware, including science experiments for use on Mir, have a safety certificate that documents the results of the safety analysis and certifies that it is safe for operation on Mir.

Since the Mir fire in the Solid Fuel Oxygen Generator, NASA has been involved in assessing safety risks of astronauts on Mir both before and after each Shuttle mission. This has been achieved through the understanding of anomalies experienced during Mir stand-alone operations, the assessment of the ability of Mir to meet the jointly agreed-to major Mir life support system requirements to allow U. S. astronaut to continue, and the real-time presence of flight operations, science, and flight medical personnel in the Mission Control Center in Moscow.

The agreed-to Mir life support system requirements identify the atmosphere and environment, such as Oxygen and Carbon Dioxide levels, as well as temperature and humidity. In addition, it identifies 30-day reserve of food and water, number of fire extinguishers and gas masks onboard, redundancy of oxygen and carbon dioxide removal system, contaminant removal system, physical exercise devices(and conditions permitting their use), and the availability of a functioning Soyuz return vehicle. This agreement does allow for the use of maintenance and critical spares to recover redundancy. It also identifies conditions that would require the return of the Mir crew in the Soyuz(loss of habitable atmosphere, medical emergency, loss of capability to combat a fire).

The Mir system failures that affect safety and the associated corrective actions are documented in our Joint Safety Assurance Working Group Document 3-5M. On the major failures like the fire, our Russian partners allowed NASA participation in the failure investigation, provided drawings, systems description, debrief of cosmonauts at Star City, and attendance at the final Commission meeting on the cause of the fire.

Our increasing knowledge of and insight into Mir operations and systems has greatly improved our ability to understand the safety risks for continued operations on the Mir. Our conclusion is that the Program can continue at an acceptable level of safety risk that is no greater today than was present in the past.

Early Mission Termination

The second most significant risk to be addressed is that of an early mission termination due to an accumulation of systems failures or other circumstance conspiring to make continued habitation of the Mir untenable. The issues associated with this are twofold: the safe return of our crew on the Soyuz, and the loss of the science planned for the remainder of the Program.

NASA has determined that there are no significant issues associated with our crew returning on the Soyuz. This was the foundation for the decision to accept the Soyuz escape capability as part of the rationale for safe presence on the Mir, and the decision is still considered valid. Recent concerns about the early operation of the soft landing engines on the Soyuz and the resulting hard landing have been resolved. The Soyuz is designed to safely return the crew even without the rockets, and no injuries were sustained in either of the two such landings to occur (17 years apart). Investigation of allegations that injury would have been sustained had there been a third crew in the last Soyuz has indicated that this would not have occurred. No damage was sustained by the seat or the hardware carried in it, although the seat supports did not stroke to absorb the landing impact due to interference with the fabric liner of the module. The Russian specialists indicated that the interference would not have occurred had a proper inspection and configuration of the seat mechanism been performed prior to landing. It is believed that the lack of a human occupant led to this oversight.

Loss of Science Productivity

The most likely risk to be realized by the program is the loss of science productivity, due either to an early termination of the mission as mentioned above, or due to reduction of critical resources such as power, crew time, or communications. While most likely of the three types of risk, the consequences are also the least severe and the most manageable.

The overriding consideration with regard to this risk is that there is no alternative to accepting it other than to realize it immediately. In other words, to proceed is to accept the risk that some of the science may not be realized and some of the money spent in preparing it will be lost. On the other hand, termination and other unavoidable program costs mean that a decision to not send our crew will not save significant money while guaranteeing that the majority of the science program will not be accomplished.

On this basis the choice to go forward and achieve as much as possible is the obvious path to follow.

Perceived Risk Areas

Some areas of the program are perceived as having significant risks associated with them. One area of heightened interest and perceived risk is the potential impact to safety and mission success of the Mir's maintenance activities. The crews have daily regimens of Mir housekeeping chores, and weekly vehicle cleanups to keep the Mir systems running. In addition to these planned procedures, there are additional, sometimes unplanned in-flight maintenance activities that the crew must accomplish.

The crew's maintenance activities do include some activities incurred by vehicle systems failures. From the time that the Mir Program decided to operate until failure, the crew has had to contend with unplanned hardware replacements. This operations philosophy initially saves the program crew time, as unnecessary hardware changeouts are now avoided. However, when the item does eventually fail, the crew's timeline must then be adjusted to allow for the in-flight maintenance to be accomplished. Backup capabilities exist to give the crew adequate time to respond. Should the Elektron stop functioning, the crew has both gaseous oxygen supplies brought up on Progress, and the lithium perchlorate cassettes available to support the oxygen requirements while the repairs are completed. Should the Vozdukh carbon dioxide removal system fail, there is a supply of lithium hydroxide on-board to accomplish the carbon dioxide removal while the system is repaired. Should the Urine processing system fail (the system that processes urine into technical water for use in the Elektron for oxygen production), there is a supply of Urine preservative and many storage containers on-board to hold the urine until the processing system can be repaired. All of these examples demonstrate that the Mir operations for the critical life support functions, while requiring maintenance, have sufficient dissimilar backup capabilities that can safely be operated until failure.

This mode of operation does impact the crew timeline when failures do occur; however the impacts to operations are not correctly reflected in the media. A failure of the Elektron near the crew's planned sleep period will more than likely have the crew shut it off and go on to bed, leaving the troubleshooting steps to the next day. The next day will begin with the crew utilizing a lithium perchlorate cassette to raise the oxygen levels, eat breakfast and set about the day's activities which will include troubleshooting the shutdown of the Elektron. This response to the failures is routine.

The last area of perceived risk to be addressed is the area of language communication. There is a potential for the crews to misunderstand each other due to the fact that not all crew members are native Russian speakers. This risk is controlled in a number of ways. Activities that contain more risk are rehearsed. Those that require crew-to-crew coordination are practiced pre-flight, and some cases in-flight, to familiarize each member of the crew with their roles and responsibilities. Activities such as these include emergency procedures for evacuation to the Soyuz and EVA procedures. For other activities, additional response time is available to allow for crew members to communicate, and come to agreement on activities to be performed.

A Reminder of Our Mission

The difficulties experienced by the Mir Station and its crews over the past several months have raised questions in the minds of many individuals, which have undoubtedly contributed to the need felt to call this hearing. I look forward to addressing more of those concerns and others as this hearing proceeds. I believe strongly in the importance of accountability in government service, and I believe that the hard questions asked by this Committee and others can only help to ensure that we miss no detail in our efforts to evaluate the viability of continuing the Phase 1 Program long-duration missions in a way that enhances safety.

I believe that there are two broad questions of which most others are a subset:

1. Is there sufficient value and benefit to be gained from continuing the missions aboard Mir?
2. Can we conduct those missions safely?

I have already addressed in some detail the reasons I believe we can positively answer the second question. To answer the first question, I will briefly review the experience and lessons learned in the Phase 1 Program from the standpoint of our four primary goals.

1. Learn to work together with each other, both in space and in ground support activities.

The Phase 1 Program has already resulted in the development of positive and effective relationships between the space agencies, mission planners, managers and controllers, contractors and counterpart individuals of both the US and Russia in a way that would have been considered unthinkable a decade ago--or even five or six years ago. Last week, we saw US astronaut Mike Foale participating in a critical repair EVA outside the Mir Space Station. I cannot stress enough how much that fact alone bears witness to the success of this program. When we started the Phase 1 Program in 1993, we still knew very little about the Russian space program and how it functioned. But as the Program has progressed, we are no longer guests, but are active participants--partners, really--in the operations of the Mir Space Station.

We have become a part of the Russian control center and have learned a great deal about how they operate, including things we wish to include in ISS as well as those we do not. During critical periods, they are well staffed with people with years of experience and do an excellent job. During periods of low activity on board the station, the response is less crisp. The NASA mission oversight role is being tuned to more effectively complement the Russian control capabilities. As a result, the amount of Russian segment telemetry monitored by NASA will be increased for the balance of Phase 1 as well as for ISS. In addition, we have implemented a more specific and more active role for our premier Mission Directorate personnel.

The following are several additional examples of what we have gained thus far in pursuing the goal:

Rendezvous/Proximity Operations/Docking - The opportunity to actually fly to and dock with a space station with the Shuttle has provided invaluable operational lessons that will be applied to the ISS. For example, all of the techniques required for ISS docking and undocking have been flight tested and proven all the way through actual operations. We have learned how to operationally launch and rendezvous with targets in high inclination. We are verifying in flight the procedures for use and the effects on the station of the Shuttle maneuvering thrusters. We are developing all necessary contingency breakout procedures and the nominal procedures for inspection fly arounds. We developed and practiced the joint procedures for pressurization and ingress of transfer compartments post docking and preparation for undocking. In addition, we tested the use of various sensors and confirmed that we needed a "tracking light" for the ISS.

Mated Operations - Phase 1 allows us to demonstrate how to use the Shuttle for attitude control of large flexible structures. This is a significant task, critical for early ISS operations. We have exercised the sharing of operational responsibility during which the Russians are responsible for the Russian segment and the US is responsible for the US segment (in the Phase 1 case, the Space Shuttle). We have observed the Russians' operation of a long duration space station and observed the pros and cons of the current Russian strategies. Their philosophy concerning spares is a case in point; they generally operate their non-mission critical hardware until it fails, as we will on ISS, and have a good data base of what is likely to fail and what spares should be maintained on-orbit. These skills will be critical for ISS and the lessons are being factored into the US plans.

Training - The Russians train for systems skills rather than for flight specific tasks. This is a natural approach for long duration missions such as the ISS. The U.S. crews and instructors are becoming more accustomed to this strategy. Phase 1 has validated the basic concept that skills based training is appropriate for long duration missions. Phase 1 has also shown that it is extremely important that training plans are documented and implemented by both sides. We have learned that a continued U.S. presence at Gagarin Cosmonaut Training Center is necessary to insure continuity in training. This aspect includes day to day scheduling and assurance that U.S. medical doctors are present during safety related sessions. These activities have been critical in all areas of training including science and Mir systems, and plans are in place to continue this philosophy and allocation of personnel for Phase 2, with an increase in personnel commensurate with the increased on board activity.

Multi-National Operations and Control Center Coordination - NASA has learned how to conduct operations using interpreters, accounting for time shifts of 9 hours, and with redundant responsibility for operations between Control Centers. This will be required on ISS where the partners will provide payload control of their modules. We have worked out how to exchange documents, how to organize them, and how to make it clear who is responsible for what. The control center capabilities included voice, video, data transfer, and Mir systems data displayed in both control centers. This capability is going to be used as the building block in connecting the control centers for ISS. In fact, the planned ISS tools for flight planning and procedures development are already installed in both the US and Russian control centers. We will have years of experience working together before we even begin operating the ISS.

In addition to conducting the US program on Mir, we have had the opportunity to participate in Mir activities that included participation by the European (ESA) and German (DARA) space agencies. There is also a French (CNES) flight planned for January of next year, in which

NASA will participate. We have done joint timelining, shipped ESA and DARA telemetry data from the Mir on US systems and distributed it to the ESA and DARA control center in Germany. We have numerous science payloads that have Co-Principal Investigators from different countries. In truth we are participating in a multi-national program on Mir that is the precursor to the ISS flight operations phase.

2. Reduce the risks to International Space Station development and operations by testing hardware, refining joint procedures and integrating the operational practices of the two nations with primary operational responsibility for the International Space Station.

The International Space Station (ISS) Phase 1 Risk Mitigation Experiments (RMEs) and Technology Demonstrations (TDs) program includes tests that reduce the technical risks associated with the construction and operation of ISS.

The RMEs & TD tests are categorized in five functional areas:

A.) Environmental Characterization B.) Structural Dynamics C.) Crew Health Care
D.) Operational Techniques Development E.) Technology Demonstration/Hardware Evaluation

A. Environmental Characterization - The environmental characterization area contains experiments whose goals are to characterize the external space environment at the 51.6 degree orbital inclination by direct measurement of micrometeoroid, debris particles, and cosmic radiation levels. Photographic and video images of the Mir space station's exterior are being made in order to document the effect of this environment on large space structures. Measurements of the Mir internal environment are being made to aid in understanding the living conditions in the Russian modules.

Preliminary Results/Phase 2/3 Benefits:

* The Plume Impingement and Contamination experiment was able to define the levels of plume induced contamination for both Shuttle and Mir thrusters; the estimated plume contamination levels are needed for ISS calculations of hardware logistics needs and assessment of material degradation resulting from plume infringement.
* Measurements and the results obtained from the Radiation Monitoring Equipment - III, Cosmic Radiation & Effects Activation Monitor, and the Real-time Radiation Monitoring Device experiments will be used to validate or modify the current models of the space radiation environment (for example to account for trapped particles and spacecraft shielding); the real-time radiation device estimates dose rate and dose equivalents for crew members.
* Data from the Mir Audible Noise Measurement experiment showed where modifications can be made in ISS systems to meet the criteria for noise levels. Further investigations are planned.
* The Mir Electric Field Characterization experiment recorded the electromagnetic conditions at the Mir/ISS inclination, which is important information for the design of equipment aboard the ISS.
* Photographic and video images from the Micrometeoroid/Debris Photo Survey of Mir have aided

in the understanding of the external environment at the ISS operational inclination, providing important information for protective mechanisms for the ISS; contamination deposition observed on some Mir surfaces has prompted changes to purge and venting port orientations on ISS to preclude deposition on sensitive surfaces such as solar arrays and radiators.

* The Mir Environmental Effects Payload, consisting of the Passive Optical Sample Assemblies 1 & 2, Orbital Debris Collector, and the Polished Plate Micrometeoroid Debris Collector, will yield similar valuable data after return on Shuttle flight STS-86. The Optical Properties Monitor will return data on flight STS-89.

B. Structural Dynamics - Experiments and tests in this area are designed to provide data for the verification of ISS loads and dynamics mathematical models.

Preliminary Results/Phase 2/3 Benefits:

* Data collected during crew motion/loads experiment of the Enhanced Dynamics Load Sensor identified the impact of crew activities and are being used to update station loads/dynamic models.
* The Mir structure, which varies in age from one to 11 years old, was measured with the Mir Structural Dynamics Experiment yielding important dynamics data, enabling the predicting and countering of ISS structural dynamics.

C. Crew Health Care - The crew health care area contains experiments designed to test hardware that will be used to support and improve the quality of life on the ISS. Some hardware components in this area are felt to be particularly sensitive to micro-gravity operation.

Preliminary Results/Phase 2/3 Benefits:

* The Water Microbiology Monitoring/Water Experiment Kit used on the Mir performed as expected and crew comments state that the kit is well suited for spaceflight use.
* The Crew Medical Restraint System deployment took 56 seconds in zero-g which is well within the requirement for the restraint system.
* The analytical results on Water Quality Monitor (WQM) operation were within the prescribed acceptance levels with the exception of pH and Mir hot water total organic compound values. Levels of these parameters were exceeded, but not to a degree which thewould adversely affect potability of the water.
* Unexpected WQM experiment hardware leakages found post flight necessitate design changes which are being implemented for the ISS unit.
* The Volatile Organics Analyzer and Volatile Removal Assembly will be tested on Shuttle flight STS-89.

D. Operational Techniques Development - The operational techniques development area contain experiments that will provide data on how best to perform specific station assembly tasks via EVA, how to track the transport of supplies and logistics between spacecraft, and test what procedures are best for performing routine in-flight activities.

Preliminary Results/Phase 2/3 Benefits:

* Specific station Extra Vehicular Activity (EVA) assembly and maintenance tasks were demonstrated through the use of a "Task Board"; the crew rated the majority of the tasks as "acceptable" which validates a number of ISS EVA hardware design concepts.
* Design of ISS EVA support hardware such as the cable caddy and Orbital Replaceable Unit grid latch assembly were determined to be acceptable by the EVA crew as a result of the inflight evaluation of the hardware.
* The Shuttle/Mir Alignment Stability Experiment produced valuable data on the characteristics of the docked Shuttle/Mir stack, which can be used to predict the dynamics of Shuttle docking to ISS.
* Data collected by the Inventory Management System experiment has improved planning for ISS operations for transferring materials and supplies.

E. Technology Demonstration/Hardware Evaluation - Experiments and tests in this area evaluate the designs and capabilities of candidate hardware to be used on ISS. The data from the experiments and tests will be used to assess the soundness of the design prior to utilization on the ISS. Some of these experiments will test techniques developed to isolate and mitigate micro-gravity environment disturbance sources.

Preliminary Results/Phase 2/3 Benefits:

* Global Positioning System and navigation experiments identified antenna pointing and receiver channel requirements and real-time navigational processing techniques which impact the accuracy of docking with ISS; attitude and navigation algorithms planned for ISS will be updated.
* Data from the Wireless Data Acquisition tests show the utility of the system in being able to acquire temperature, pressure, and strain gauge data via radio frequency link.
* The results of the Photogrammetric Appendage Structural Dynamics Experiment show that the photogrammetric measurement technique without the use of optical targets is a viable option that can be used to determine appendage structural dynamic responses. This technique may be used by the ISS structural loads verification group.
* The results of the Active Rack Isolation System (ARIS) experiment show that the basic 6 degree-of-freedom control algorithm is valid and does not require any significant modification for rack vibration isolation on ISS. Findings from the failure investigation of actuator/pushrod anomalies were incorporated into the Critical Design Review activities for the ISS ARIS.
* TheTreadmill Vibration Isolation and Stabilization (TVIS) experiment demonstrated a stable running platform with minor pitch oscillation associated with fore-aft shifting of the runner. Design elements of TVIS will be used in the ISS treadmill.
* Preliminary results from the Microgravity Isolation Mount (MIM) experiment indicate that it can reduce station vibrations from several milli-g to 50 micro-g peak to peak for experiments mounted on the MIM floater, an improvement of two orders of magnitude. Evaluation of the use of the MIM to isolate sub-rack payloads on the ISS is underway.

3. Gain experience in long-duration stays on a space station and develop effective bio-medical countermeasures to the effect of extended weightlessness.

and

4. Conduct scientific and technological research in a long-duration environment, gaining both valuable research data and developing effective research procedures and equipment for use in the International Space Station

Except for the Skylab Program in the mid-1970's, U.S. space research conducted on crewed platforms has been limited to relatively short durations of up to about 18 days, the maximum length of a Space Shuttle mission. A long-duration platform such as Mir opens up research opportunities that are not only impossible on the ground but also impossible on the Shuttle. There are significant procedural differences between conducting science on a Shuttle mission and on a long-duration platform that cannot fully be appreciated and understood without the experience of both programs, an experience the Phase 1 Program has provided.

The research program for the first US astronaut on Mir primarily focused on biomedical investigations, an area where the US and Russian space programs already had a long-standing relationship at the level of scientific exchanges. As the Phase 1 program matured and possibilities developed to launch Shuttle and Spacelab-class facilities to Mir aboard the Spektr and Priroda modules, the research program became multi-disciplinary, spanning disciplines such as Earth Observation, Fundamental Biology, Human Life Sciences, Microgravity Sciences and Space Sciences. In addition, Mir has been used as a test-bed to demonstrate advanced technologies and operations to better prepare for the International Space Station.

To date, about 120 investigations spanning a wide variety of research disciplines have been conducted aboard Mir as part of the Phase 1 Research Program. Phase 1 Investigators include leading scientists from the United States, Russia, Canada, France, Germany, Hungary, and Japan. Many of the Principal Investigators have flown experiments on the Shuttle and on Spacelab missions, and in many cases their goal was to conduct experiments on Mir similar to their previous Shuttle work to identify the differences in results between short-duration and long-duration space flight.

Of prime importance from both a science and a crew health perspective is the monitoring of the Mir's environment. Equipment and procedures for the proper monitoring of such vital factors as Mir's air and water quality, its microbiological and chemical components, and internal and external radiation levels, have been validated and will continue to be used on ISS. These studies have concluded that the Mir environment is safe for crew members, and in the case of occasional temporary incidents, proper monitoring and adequate protective measures are available. New findings about the South Atlantic Anomaly's northwestward migration have been published based on results from Mir, and a better understanding of the solar cycle has been made possible.

Another important aspect of the research program is the study of the crew members themselves and their responses to long periods in weightlessness. These investigations allow more precise characterization of human physiology and psychology in space, in particular changes in bones and muscles, the neurovestibular system, the risk of developing kidney stones in space, and changes in the interactions among crew members and their ground support team over the course of the mission. The space flight-induced changes seen in muscles and bones are similar to those seen in bedridden or osteoporotic patients. Better characterization of these changes in healthy crew members may lead to better methods of rehabilitation and treatment for patients on Earth.

In the area of production of crystals of proteins and other substances, new techniques and methods have been verified during the Phase 1 program. These techniques have provided both qualitative and quantitative improvements over ground-based and previous space-based experiments. Analysis of the higher quality crystals grown on Mir permits better understanding of their molecular structure, leading to better understanding of viral interactions with antibodies, enzyme functions, and possibly new pharmaceutical products.

The area of tissue culturing in space holds great promise, both in the near-term for understanding how different tissues interact and ultimately for learning more about how live tissues can be used. A significant advancement in this field was accomplished on NASA-3; the duration of tissue growth experience was extended from 10 days to 4 months, with the successful culturing of cartilage cells in an onboard bioreactor.

Of scientific interest for botanists and for logistical and crew psychological support benefit for ISS and future space programs is the ability to grow plants in weightlessness. A significant first in this area was achieved during the Phase 1 program: seeds generated by plants grown in space were planted and in turn germinated and grew plants, the first so-called "seed-to-seed" experiment in space. This is a significant first step in the ability to support widespread plant growth and cultivation in space. In a positive irony, these plants grew and this space first was achieved after the Spektr collision and during the low-power period on Mir.

The trained astronauts on Mir have added substantially to the growing database (about 300,000 images) of Earth observation photographs from US human space flights. One added benefit provided by crew members aboard Mir is during their months-long mission, they are able to observe and record long-term and seasonal changes in various areas of interest. Agricultural and other land-use patterns, such as global deforestation and drying up of lakes can be monitored over long periods of time. In addition, astronauts have observed and photographed rapidly occurring events such as volcanic eruptions and fires that otherwise may have gone unobserved.

Russian, Canadian and U.S. facilities aboard Mir have been used to perform experiments in fluid physics, combustion science, colloid science, metallurgy and diffusion of liquids such as metals heated in a furnace. The facilities included furnaces, a glovebox to contain experiments as required, and a system to isolate experiments from the station's vibration environment. Some experiments tested and verified or modified basic theories in fluid physics. The controlled combustion experiments provided a better understanding of how flames propagate in weightlessness. Colloids, solid particles suspended in liquid, are seen in every day life as cosmetics, paints and other industrial products, and their study in weightlessness without the disturbing influence of gravity can lead to better commercial products here on Earth. Overall, the conclusion has been that the Mir is an adequate facility for conducting these types of experiments.

From a variety of experiments, we have learned and will continue to learn about Mir's external environment, which in many cases will be similar to the external conditions around ISS. Sensors placed on the outside of Mir and designed to collect microscopic particles have shown that these particles vary from micrometeoroids to leftover specks from spent rocket stages. It has also been shown that large detectable pieces of orbital debris in some cases may be accompanied by clouds of particles too small to detect, but that may also cause deterioration of solar panel cells and other external structures.

In addition to the wealth of research data still coming in from the on-going Phase 1 program, the U.S. continues to gain valuable experience into how to design, train for, operate and improve upon research on a long-duration platform. One basic factor is that the research program should be viewed not only in the sense of what can be accomplished on a single mission but in the course of the whole program. As long as the hardware remains safe on orbit, and a crew member is trained in its operation, if it becomes necessary, a particular experiment may be performed at a later date, or even on a later mission. Preflight planning for a long-duration flight must take into account that it is virtually impossible to predict at the start of the mission, what exactly will happen in the second or third month of the flight, and this flexibility must be built in. In-flight replanning is also done differently, in that in most cases, more time is available as compared to short-duration missions. Pre-mission training of crew members, while it still must result in crew members able to carry out the mission and the scientific experiments, must also take into account that it may be weeks or even months before certain activities trained for on the ground will actually be performed on-orbit. The capability to retrain or at least provide refresher training during the mission must be built in. These and other lessons learned from Phase 1 will immensely help the utilization of ISS.

Because of the on-going nature of the Phase 1 Program, not all the results are in yet, and some of what has been reported is still preliminary and awaits additional subjects or data sessions to reach more definitive conclusions. Many of the experiments performed on previous Mir missions will be continued on Dr.Wolf's and Andy Thomas' flights, but of the 35 experiments now planned for Dr. Wolf, there will be new activities in the following areas: detection of cosmic radiation, test of a new portable computer system, new methods in developing and analyzing real-time the growth of protein crystals, and a new experiment in tissue culture.

There is Much More to be Learned

When you are exploring new territory, or preparing yourself to take a major step into the unknown, who can say when you have learned enough?

This nation, and its partners, are about to embark on a thirteen-year journey into the assembly and operations of the International Space Station. There has never been a more ambitious or more complex engineering challenge in history. The investment in time, talent and resources is large, though everything possible has been done to minimize the cost. It is clearly an investment worth protecting by learning everything that can be learned about what to expect in its environment and during its operations before the first elements are launched next year.

Operational experience

The recent increase in the involvement of NASA personnel in the day to day operation of the Mir space station vehicle is paying huge dividends for our operations and design teams. The involvement of the operations personnel allows them to develop and validate techniques for managing systems and consumables on ISS, and it also permits them to verify that the design requirements applied to ISS are appropriate. This is a very significant and valuable change from our original role which was limited to being the science customer on Mir.

The Mir can be considered a laboratory for conducting experiments in the operation of a long duration spacecraft. NASA's previous experience with crewed vehicles was gained almost entirely on missions of 15 days or less duration, and especially in the case of Shuttle missions, the option of terminating the mission early and landing in an emergency has almost always been available. Therefore, the vehicle systems design, operational flight rules, and logistics support have all been tailored with that option available, much as an aircraft emergency procedure is always terminated with instructions to "land as soon as practical."

However, a long duration vehicle requires a different approach, one having more in common with a ship at sea than an aircraft in flight. It is not designed to ever land intact, and in fact abandonment may cause loss of the station due to premature reentry. Therefore, different designs and operational approaches must be developed to deal with the systems failures and maintain safety standards in the face of a significant maintenance burden.

The next two long-duration missions will be giving our flight controllers and systems specialists experience in disciplines as diverse as life support and flight dynamics to logistics and maintenance, as well as providing an outstanding opportunity to see real world results from operational decisions. In addition, we are already seeing our inputs accepted in some arenas and will be able to directly observe the effects of the decisions. Also important is that this opportunity comes aboard a station whose operating characteristics are well known and understood, and that its development costs have already been recovered. This allows us to get critically important experience that can protect our multi-billion dollar investment in ISS at almost no monetary risk to the US.

Continuing Phase 1 until the beginning of ISS assembly, as planned, enables us to ensure that the body of knowledge developed among our controllers and managers can transition more smoothly to meet the operational needs of the ISS, beginning in June of next year. To stand that human resource down now, for six months, would almost certainly result in a lengthy--and costly--learning curve at a time when we need immediate proficiency in managing a growing space station.

Risk Mitigation Experiments - Final Phase 1 Shuttle Flights and Increments

The remaining flights will allow completion of the Mir Structural Dynamics Experiment (MiSDE) Shuttle/Mir and Mir alone activities. Data from this experiment is needed in order to perform the verification of integrated loads and dynamic models of the early stages of the ISS when each module added greatly changes the characteristics of the growing station. Mir jet firings not obtained on previous flights during the docked operations will be obtained. Additional data taken during the Mir alone operations is needed to increase the data set used for ISS structural dynamic model assessment. The fidelity of the model directly affects the operational envelope of the station which drives costs, mission flexibility, and mission success.

A crucial part of the water investigations is yet to be accomplished. The Volatile Organics Analyzer and Volatile Removal Assembly will be tested on Shuttle flight 89 to Mir. Data from these experiments will affect the control of water quality on ISS and allows for water recycling. The resupply requirements for water, which is a high cost driver, can be greatly affected based on water quality.

Radiation characterization data on the ISS Portable Computer System (PCS) laptop will be obtained in this final Phase 1 timeframe. Single Event Upset (SEU) potential on PCS firmware will be evaluated in the ISS destined environment. Data could show that redesign and/or protective measures need to be taken to insure the laptops can perform their intended functions. The PCS is key to crew member interaction with the ISS computer system, directly affecting ISS mission success.

Beneficial long term environmental characterization data on candidate and baselined materials used for ISS construction and the effect of space environment on materials currently in space will be gathered from these missions. Data from the Optical Properties Monitor (OPM) and the Space Portable Spectroreflectometer (SPSR) will be returning in order to allow detailed assessments of coupon materials exposed by the OPM and the interrogation of the SPSR. They will be retrieved/used during a planned EVA in several months time. The Optical Properties Monitor will be returned for ground analysis on flight 89.

There are roughly 60 more planned science investigations for the Phase 1 Program covering many disciplines. These include national and multinational cooperative studies including remote earth observations with Priroda external sensors to study meteorological and geographical changes, advanced technology studies in commercial bioprocessing and other technologies, fundamental biology studies in active dosimetry, human life sciences studies of bone mineral loss and affects of microgravity on immune system response, characteristics of renal stone generation and countermeasures, and many more.

In addition, a number of experiments which have been flown previously have been modified, based on the prior experience. They can now be flown in their modified form to validate the design modifications which will lead them directly into application aboard the ISS,

Our intention is to complete Dr. Wolf's mission, and then to carry out the final planned Phase 1 increment, thus continuing to gain the experience needed to better understand our relationship with the Russians, better understand the nature of long-duration spaceflight, and better understand the resources systems, hardware and operating techniques needed to help ensure the success of the International Space Station.

Conclusion

I have attempted in this statement to provide a reminder of the reasons for the United States' continued participation in the Shuttle/Mir Program, outlining a number of important benefits gained, so far, from the missions to Mir, and those yet to be accomplished.

I have offered a description of our safety assessment and review process, to illustrate the great care and great detailed examination we at NASA and our partners in Russia put into the considerations before approval of each Shuttle/Mir mission.

What I cannot offer you is a vision for yourself of what the International Space Station will be if we continue our important partnership with Russia and with the other space-faring nations who are a part of the ISS. I can tell you what I see, and suggest that many others share that particular view, but no one can really say with any certainty what the future will bring. I can tell you, based on experience, that the future of the ISS is even brighter as a result of the Phase 1 Program. Immeasurable resources in time and money that might have been spent to learn costly lessons through inexperience will now be able to be used to conduct important, perhaps life-saving, scientific activity.

As of this moment, we are prepared to continue with the launch of STS-86, to deliver David Wolf to the Mir for the sixth long-duration mission of the Phase 1 Program. On the 23rd of September--two days before the launch--we will conduct a final review, closing any open issues, and making a final determination to proceed with the launch.

At every step along the way of that mission, from the go to rendezvous and dock, to the go to transfer crew and undock, and continuously throughout the mission, as always, we will monitor and assess the situation aboard Mir. If at any time we determine that it is unsafe for the crew to remain aboard Mir we will ask the Russians to bring them home. And they will come home.

In the meantime, we will continue to reap the benefits of this extraordinary experience and make what we believe is a unique and irreplaceable contribution to the ultimate safety and efficiency of the International Space Station.

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