

Aerospace Safety  
Advisory Panel  
ANNUAL REPORT FOR 2001



## Report Documentation Page

<b>Report Date</b> 00Mar2002	<b>Report Type</b> N/A	<b>Dates Covered (from... to)</b> -
<b>Title and Subtitle</b> Aerospace Safety Advisory Panel ANNUAL REPORT FOR 2001	<b>Contract Number</b>	
	<b>Grant Number</b>	
	<b>Program Element Number</b>	
<b>Author(s)</b>	<b>Project Number</b>	
	<b>Task Number</b>	
	<b>Work Unit Number</b>	
<b>Performing Organization Name(s) and Address(es)</b> National Aeronautics and Space Administration Headquarters Washington, DC 20546-0001	<b>Performing Organization Report Number</b>	
<b>Sponsoring/Monitoring Agency Name(s) and Address(es)</b>	<b>Sponsor/Monitor's Acronym(s)</b>	
	<b>Sponsor/Monitor's Report Number(s)</b>	
<b>Distribution/Availability Statement</b> Approved for public release, distribution unlimited		
<b>Supplementary Notes</b> The original document contains color images.		
<b>Abstract</b> see report		
<b>Subject Terms</b>		
<b>Report Classification</b> unclassified	<b>Classification of this page</b> unclassified	
<b>Classification of Abstract</b> unclassified	<b>Limitation of Abstract</b> SAR	
<b>Number of Pages</b> 69		

“The Panel shall review safety studies and operations plans referred to it and shall make reports thereon, shall advise the Administrator with respect to the hazards of proposed operations and with respect to the adequacy of proposed or existing safety standards, and shall perform such other duties as the Administrator may request.”

NASA Authorization Act of 1968 | Public Law 90-67, 42 U.S.C. 2477

National Aeronautics and  
Space Administration

Headquarters

Washington, DC 20546-0001



Q-1

March 2002

The Honorable Sean O'Keefe  
Administrator  
National Aeronautics and Space Administration  
Washington, DC 20546

Dear Mr. O'Keefe:

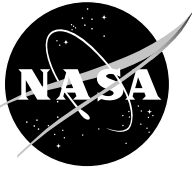
The Aerospace Safety Advisory Panel herewith submits its Annual Report covering calendar year 2001. This report presents a high level of concern for future safety while recognizing the significant current achievements of NASA's aeronautics and space programs. The reasons for this apparent dichotomy are explained in Section II of the report and reflected in the various specific findings and recommendations.

The Panel appreciates the full cooperation provided by NASA and contractor personnel. This report was greatly facilitated by their efforts and candor.

Sincerely,

A handwritten signature in black ink that reads "Richard D. Blomberg". The signature is written in a cursive, flowing style.

Richard D. Blomberg  
Chair  
Aerospace Safety Advisory Panel



National Aeronautics and  
Space Administration

# Aerospace Safety Advisory Panel

A N N U A L R E P O R T F O R 2 0 0 1

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**Aerospace Safety Advisory Panel**

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# I. Introduction



## Introduction

This Annual Report of the Aerospace Safety Advisory Panel (ASAP) presents results of activities during calendar year 2001. The year was marked by significant achievements in the Space Shuttle and International Space Station (ISS) programs and encouraging accomplishments by the Aerospace Technology Enterprise. Unfortunately, there were also disquieting mishaps with the X-43, a LearJet, and a wind tunnel. Each mishap was analyzed in an orderly process to ascertain causes and derive lessons learned. Both these accomplishments and the responses to the mishaps led the Panel to conclude that safety and risk management is currently being well served within NASA.

NASA's operations evidence high levels of safety consciousness and sincere efforts to place safety foremost. Nevertheless, the Panel's safety concerns have never been greater. This dichotomy has arisen because the focus of most NASA programs has been directed toward program survival rather than effective life cycle planning. Last year's Annual Report focused on the need for NASA to adopt a realistically long planning horizon for the aging Space Shuttle so that safety would not erode. NASA's response to the report concurred with this finding. Nevertheless, there has been a greater emphasis on current operations to the apparent detriment of long-term planning. Budget cutbacks and shifts in priorities have severely limited the resources available to the Space Shuttle and ISS for application to risk-reduction and life-extension efforts. As a result, funds originally intended for long-term safety-related activities have been used for operations. Thus, while safety continues to be well served at present, the basis for future safety has eroded.

Section II of this report develops this theme in more detail and presents several important, overarching findings and recommendations that apply to many if not all of NASA's programs. Section III of the report presents other significant findings, recommendations and supporting material applicable to specific program areas. Appendix A presents a list of Panel members. Appendix B contains the reaction of the ASAP to NASA's response to the calendar year 2000 findings and recommendations. In accordance with a practice started last year, this Appendix includes brief narratives as well as classifications of the responses as "open," "closed," or "continuing." Appendix C details the Panel's activities during the reporting period.

The year 2001 was one of significant upheaval on the Panel and within NASA's top management. In April, NASA adopted a new charter for the ASAP that required a rotation of the membership. Shortly thereafter, five of the nine members and two consultants were asked to step down to initiate the succession. One other member left the Panel at about the same time. In response, the Panel's previously developed succession plan was implemented, resulting in a full complement of members and consultants within a relatively short time. Still, activities were delayed, and the new members and consultants were only becoming fully integrated into the Panel's activities as the year drew to a close. Nevertheless, the Panel completed most of the inquiries planned at the beginning of the year. In addition, it responded to several special requests from NASA, such as a review of the safety implications of performing orbiter structural inspections at the Kennedy Space Center (KSC) rather than at the Palmdale facility, an examination of the security preparations at KSC for the first Space Shuttle launch after the September 11 attacks and an assessment of the approach to information system redundancy aboard the ISS.

Panel personnel changes involved the departure of Ms. Yvonne C. Brill, Vice Admiral Robert F. Dunn, USN (Ret.), Dr. Seymour C. Himmel, Vice Admiral Bernard M. Kauderer, USN (Ret.), Dr. Norris J. Krone, and Dr. Richard A. Volz as members, and Mr. Norman R. Parmet and Dr. John G. Stewart as consultants. To fill these vacancies, consultants Mr. Sidney M. Gutierrez, Ms. Shirley C. McCarty, Admiral J. Paul Reason, USN (Ret.), Mr. Roger D. Schaufele, and Mr. Robert B. Sieck changed from consultant to member, and Mr. Otto K. Goetz joined the Panel as a member. In addition, eight new consultants—Dr. Wanda M. Austin, Mr. Richard R. Bruckman, Dr. Ulf G. Goranson, Bernard A. Harris, Jr., MD, Dr. Nancy G. Leveson, Mr. C. Julian May, General Forrest S. McCartney, USAF (Ret.), and Mr. Arthur I. Zygielbaum—joined the Panel.

The primary focus of this report is on human space flight programs. These are NASA's most prominent efforts. They are currently under significant operational pressure supporting ISS construction and operation. Space flight programs were also the focus of the initial efforts of the newly reconstituted Panel. In the upcoming year, the ASAP plans to return to a more balanced examination of all of NASA's programs. Also, it is important to note that the findings and recommendations reported herein generally cover only those items that were still open as the year drew to a close. There were many other areas of inquiry that were initiated and resolved to the satisfaction of the Panel during the year. These are not specifically reported herein as findings and recommendations but are covered in the narrative discussions of each focal area or reflected in the activity log in Appendix C.

## II. Pivotal Issues



## Pivotal Issues

This section addresses issues that the Aerospace Safety Advisory Panel (ASAP) believes are currently pivotal to the safety of NASA's activities. Some of these issues have widespread applicability and are therefore not amenable to classification by program area in Section III. Others, even though clearly applicable to a particular program, are of such sufficient import that the Panel has chosen to highlight them here.

### A. Planning Horizon and Budgets

NASA and, in fact, the entire Country are undergoing significant change. The inauguration of a new administration and the events of September 11 have shifted national priorities. In turn, NASA's control of its finances and need for realistic life cycle costing for major programs, such as the Space Shuttle and International Space Station (ISS), have been emphasized.

The purview of the ASAP is safety. Inadequate budget levels can have a deleterious effect on safety. Clearly, if an attempt is made to fly a high-risk system such as the Space Shuttle or ISS with inadequate resources, risk will inevitably increase. Effective risk management for safety balances capabilities with objectives. If an imbalance exists, either additional resources must be acquired or objectives must be reduced.

The Panel has focused on the clear dichotomy between future Space Shuttle risk and the required level of planning and investment to control that risk. The Panel believes that current plans and budgets are not adequate. Last year's Annual Report highlighted these issues. It noted that efforts of NASA and its contractors were being primarily addressed to immediate safety needs. Little effort was being expended on long-term safety. The Panel recommended that NASA, the Administration, and Congress use a longer, more realistic planning horizon when making decisions with respect to the Space Shuttle.

Since last year's report was prepared, the long-term situation has deteriorated. The aforementioned budget constraints have forced the Space Shuttle program to adopt an even shorter planning horizon in order to continue flying safely. As a result, more items that should be addressed now are being deferred. This adds to the backlog of restorations and improvements required for continued safe and efficient operations. The Panel has significant concern with this growing backlog because identified safety improvements are being delayed or eliminated.

NASA needs a safe and reliable human-rated space vehicle to reap the full benefits of the ISS. The Panel believes that, with adequate planning and investment, the Space Shuttle can continue to be that vehicle.

It is important to stress that the Panel believes that safety has not yet been compromised. NASA and its contractors maintain excellent safety practices and processes, as well as an appropriate level of safety consciousness. This has contributed to significant flight achievements. The defined requirements for operating at an acceptable level of risk are always met. As the system ages, these requirements can often be achieved only through the innovative efforts of an experienced workforce. As hardware wears out and veterans retire, this capability will inevitably be diminished. Unless appropriate steps to reduce future risk and increase reliability are taken expeditiously, NASA may be forced to choose between two unacceptable

options—operating at increased risk or grounding the fleet until time-consuming improvements can be made.

Safety is an intangible whose value is only fully appreciated in its absence. The boundary between safe and unsafe operations can seldom be quantitatively defined. Even the most well-meaning managers may not know when they cross it. Developing as much operating margin as possible can help. But, as equipment and facilities age, and workforce experience is lost, the likelihood that the boundary will be inadvertently breached increases. The best way to prevent problems is to maintain and increase margin through proactive and constant risk-reduction efforts. This requires adequate funding.

**Finding 1:** The current and proposed budgets are not sufficient to improve or even maintain the safety risk level of operating the Space Shuttle and ISS. Needed restorations and improvements cannot be accomplished under current budgets and spending priorities.

**Recommendation 1:** Make a comprehensive appraisal of the budget and spending needs for the Space Shuttle and ISS based on, at a minimum, retaining the current level of safety risk. This analysis should include a realistic assessment of workforce, flight systems, logistics, and infrastructure to safely support the Space Shuttle for the full operational life of the ISS.

## B. Upgrades

The Space Shuttle is not unique compared to an aging aerospace vehicle that still possesses substantial flight potential and has yet to be superseded by significant new technology. Any replacement for the Space Shuttle will likely take a decade or more to be designed, built, and certified. Commercial airlines and the military have faced the same situation and have implemented timely product improvement programs for older aircraft to provide many additional years of safe, capable, and cost-effective service.

The Space Shuttle program is not presently able to follow this proven approach. Responding to budgetary pressures has forced the program to eliminate or defer many already planned and engineered improvements. Some of these would directly reduce flight risk. Others would improve operability or the launch reliability of the system and are therefore related to safety. In addition to the obvious safety concern of loss of vehicle and crew, the Panel views anything that might ground the Space Shuttle during the life of the ISS as an unacceptable increase in safety risk due to the potential loss of the ISS and associated risk for people on the ground.

The Panel also believes it is not prudent to delay ready-to-install safety upgrades, thus continuing to operate at a higher risk level than is necessary. When risk-reduction efforts—such as the advanced health monitoring for the Space Shuttle Main Engines, Phase II of the Cockpit Avionics Upgrade, orbiter wire redundancy separation, and the orbiter radiator isolation valve—are deferred, astronauts are exposed to higher levels of flight risk for more years than necessary. These lost opportunities are not offset by any real life cycle cost savings.

The stock of some existing Space Shuttle components is not sufficient to support the program until a replacement vehicle becomes available. Some of the upgrades, in addition to improving safety, solve this shortfall by providing additional assets. If these upgrades are not going to be implemented, the program must plan now for adequate quantities of long lead-time components to sustain safe operations.

**Finding 2:** Some upgrades not only reduce risk but also ensure that NASA's human space flight vehicles have sufficient assets for their entire service lives.

**Recommendation 2a:** Make every attempt to retain upgrades that improve safety and reliability, and provide sufficient assets to sustain human space flight programs.

**Recommendation 2b:** If upgrades are deferred or eliminated, analyze logistics needs for the entire projected life of the Space Shuttle and ISS, and adopt a realistic program for acquiring and supporting sufficient numbers of suitable components.

## C. Infrastructure

The Panel recognizes that safe Space Shuttle operations require a fully capable ground infrastructure, including facilities, ground support equipment (GSE), training devices, and test and checkout gear. These assets, like the vehicle itself, are aging. Much maintenance and improvement of this infrastructure has already been deferred to conserve resources for operations. As a result, there is a large backlog of restoration and upgrade work. Unfortunately, rather than improving, the situation becomes worse each year. If restoration continues to be delayed, it will reach a point at which it may be impossible to recover.

Infrastructure becomes increasingly unreliable as it ages. At best, this will be a costly nuisance prompting delays and the need for expedited repairs. At worst, safety can be compromised if systems fail at inopportune times or multiple, simultaneous failures occur.

NASA has initiated an Infrastructure Revitalization Team to plan the activities needed through 2012, which is a necessary step in addressing infrastructure problems, but there is not sufficient funding committed to reduce the backlog of work that needs to be done. It may seem expedient to defer infrastructure maintenance and upgrades as long as the existing assets can be made to perform. While this approach can accommodate immediate needs, it has two major shortcomings: it creates a backlog of work that may never get accomplished; and it only meets short-term program needs. Neither the program's full life cycle requirements nor the needs of successor efforts are met. Infrastructure upgrades can be a valuable legacy to any vehicle that follows the Space Shuttle.

**Finding 3:** Much of the Space Shuttle ground infrastructure has deteriorated and will not be capable of supporting the Space Shuttle for its realistic service life.

**Recommendation 3:** Revitalize safety-critical infrastructure as expeditiously as possible.

The infrastructure for both the Space Shuttle and the ISS includes unique training and test facilities. Though critical to the proper preparation of flight crews, some are not heavily used—which makes their unit cost seem high. As a result, they have become candidates for outright closure or for “mothballing.” During times of declining budgets, mothballing is tantamount to closure. The Panel agrees that it is prudent to assess all facilities to determine if they are adding significantly to the readiness level of the crews or the vehicle. In cases of duplication or when an objective assessment indicates that a facility is no longer needed, closures are appropriate. However, if a facility is necessary for crew readiness, it must be retained. Also,

it is essential to consider that unique workforce skills associated with the facilities to be closed may be permanently lost.

**Finding 4:** NASA is considering closing or deactivating some training and test facilities in an effort to economize.

**Recommendation 4:** Perform a detailed full life cycle safety and needs analysis including consideration of critical skills retention before making closure decisions.

## D. Space Shuttle Privatization

NASA is exploring the concept of privatizing the Space Shuttle by securing a contractor to accept many of the responsibilities now held by the Government. It is premature to comment on any specific plans. The Panel, however, is concerned that any plan to transition from the current operational posture to one of privatization will inherently involve an upheaval with increased risk in its wake. It must be remembered that the Space Shuttle program is over 20 years old and has already undergone several transitions that were distracting for the workforce.

If a new program were conceived and designed to operate in a privatized environment, there is every reason to believe it could be successful. The salient issue is whether it is wise and beneficial to transition the Space Shuttle program to privatization. Currently, there are significant long-term safety issues that are best addressed by a fully engaged and highly experienced workforce operating in a familiar environment.

Finally, one of the stated motivations for seeking privatization is the inability of the Government to retain sufficient qualified staff given downsizing mandates. The Panel believes it is in the best interest of safety to retain a core of highly qualified technical managers to oversee complex programs such as the Space Shuttle. As long as NASA is going to be ultimately accountable for safe operations, either directly or by indemnifying a contractor, it is necessary to have the ability to make independent technical assessments. This system of checks and balances between the Government and contractors has worked well. The challenge is to define the appropriate levels of workforce and task sharing to achieve the desired benefits without excessive costs.

**Finding 5:** Space Shuttle privatization can have safety implications as well as affecting costs.

**Recommendation 5:** Include in all privatization plans an assessment by safety professionals of the ability of the approach to retain a reasonable level of NASA technical involvement and independent checks and balances.

## E. Workforce and Critical Skills

Workforce concerns continued to be a focus of the Panel during 2001. It is a tribute to the Government and contractor management that the Panel has seen no safety shortfall attributable to workforce or labor negotiation issues.

An Independent Assessment of Space Shuttle Ground Operations Processing Capability was conducted by a team from the Headquarters Office of Safety and Mission Assurance (OSMA)

during the spring when there were four orbiters in flow at Kennedy Space Center (KSC). The Panel reviewed the team report and concurs with OSMA's conclusion that United Space Alliance (USA) Ground Operations likely has the capability to safely accomplish a flight rate of up to seven per year, if staffing remains at present levels and if flights are not unreasonably clustered.

One of the current workforce challenges is the announced relocation of the sustaining engineering functions currently maintained by the Boeing Reusable Space Systems (BRSS) operation in Huntington Beach, California, to the Johnson Space Center (JSC) and KSC areas. The move has the potential to impact functions that are critical to the safe operation of the Space Shuttle, particularly since the expected number of experienced people who have actually agreed to move is well below expectations. The Panel has confirmed that BRSS and NASA managers are acutely aware of the safety sensitivity of their planned actions. Continuous oversight and unswerving vigilance by Government and contractor management will be required to safely accomplish this realignment. The Panel will continue to monitor progress as the move unfolds.

As the Space Shuttle ages, it will require innovative technical and management actions ("band-aids") to continue flying safely. Many of the most experienced NASA and contractor personnel are at or nearing retirement age. The eventual departure of these individuals will deprive the program of some of the highly skilled and experienced professionals needed to formulate and execute these "band-aids." It will therefore become increasingly difficult to know if adequate safety margins are being maintained.

The Panel believes that three major actions are needed now to compensate for the expected attrition of significant portions of the Government and contractor talent pool responsible for safe Space Shuttle operations. First, both NASA and its contractors should begin vigorous hiring and training programs as soon as possible so new people will be available to work together with the prospective retirees before they leave. Second, engineering drawings and processing work paper should be updated by the experienced workforce to assure that drawings and specifications reflect their latest experience (see Section III, A). Third, the upgrade program discussed earlier and a meaningful life-extension effort should be accomplished by the experienced workforce before they retire. It will be much more effective and efficient to task these individuals to do this work now than to have a less experienced workforce perform it in the future. If modeled after successful commercial and military aircraft life-extension programs, such efforts will reduce safety risk and simplify the tasks facing future generations of the Space Shuttle workforce. This approach will reduce the increasing reliance of the Space Shuttle on workforce experience to maintain safety.

Unfortunately, some recent ideas for achieving lower cost Space Shuttle operations could result in a reduction of NASA and contractor workforces. For example, significant cost savings from reducing from six to four flights per year will only come from staff reductions, which could exacerbate critical skills problems and disrupt the workforce.

**Finding 6:** The safety of NASA's human space flight programs will always be dependent on the availability of a skilled, experienced, and motivated workforce.

**Recommendation 6:** Accelerate efforts to ensure the availability of critical skills and to utilize and capture the experience of the current workforce.

## F. Mishap Investigation

NASA has an extensive and largely effective approach to mishap investigation. First, the severity of the event is assessed against predetermined criteria. For example, a Class A mishap is one involving death or injury or damage equal to or in excess of \$1 million. Second, a mishap investigation process is prescribed as a function of the severity classification of the incident.

The Panel typically examines the processes used in NASA mishap investigations and the resulting reports. The analysis of several of the mishaps investigated during this year led to ideas to strengthen the process.

Currently, severity classification is a function of *actual* losses. For example, an accident resulting in \$1 million in damage would necessitate a detailed investigation even if that dollar loss were the most severe possible outcome. That is fully appropriate. On the other hand, a mishap resulting in small economic loss but having *potential* for significant loss of life or assets would not necessarily result in an investigation at the highest level. NASA managers do have the prerogative to elevate an investigation to whatever level they deem appropriate, but this is seldom done as they are not required to do so.

It would not significantly increase the workload or cost associated with mishap investigation if all mishaps were prescreened by a panel of independent specialists, including the skills of accident investigation, human factors, and industrial safety. Under this approach, such a panel would review each mishap shortly after it occurred. This group would be chartered only to determine if the preset severity criteria were appropriate for structuring a meaningful investigation. If not, they would have the power to increase, but not reduce, the severity class of the event.

**Finding 7:** Mishaps involving NASA assets are typically classified only by the actual dollar losses or injury severity caused by the event.

**Recommendation 7:** Consider implementing a system in which all mishaps, regardless of actual loss or injury, are assessed by a standing panel of independent accident investigation specialists. The panel would have the authority to elevate the classification level of any mishap based on its potential for harm.

A second issue with NASA mishap investigations concerns the membership of the Mishap Investigation Boards (MIBs). In general, cognizant NASA managers populate an MIB with technical specialists in the discipline related to the accident. This is fully appropriate to provide subject matter expertise to the board. Mishap investigation is, however, a discipline of its own. Many NASA mishaps also involve complex human-machine systems. It would therefore appear appropriate to require that all MIBs (or at least those for Class A and B events) include specific expertise in mishap investigation and human factors. These disciplines are often key to determining true root causes and deriving useful lessons learned. The participating specialists need not be expert in the specific technical area, as they will draw that information from other experts on the board. It is also helpful to have experts (NASA employees or outsiders) independent of the investigated effort participate in mishap boards because they provide an important additional perspective.

**Finding 8:** There is no requirement for MIBs to include individuals specifically trained in accident investigation and human factors.

**Recommendation 8:** Adopt a requirement for the inclusion of accident investigation and human factors expertise on MIBs.

## G. Security

NASA has always been sensitive to the security of its personnel, facilities, and computing systems. In the aftermath of September 11, NASA, like many other agencies, has expanded security activities and broadened its efforts to consider nontraditional threats. The Panel has not yet had the opportunity to examine the security posture of all of NASA's Centers and facilities. Several Panel members, however, did assess the security efforts at KSC in preparation for the STS-108 launch. The Panel's computer team has also maintained an ongoing look at NASA's information technology security.

Based on these preliminary activities, the Panel believes that the ongoing processes used to arrive at security decisions are sound and capable of adapting to changes in the threat environment and/or available security capabilities. Interactions between NASA and other relevant Government organizations appear uniformly good and supportive of an integrated security activity.

# III. Program Area Findings and Recommendations



- A. SPACE SHUTTLE PROGRAM**
- B. INTERNATIONAL SPACE STATION (ISS) AND CREW RETURN VEHICLE (CRV)
- C. AEROSPACE TECHNOLOGY
- D. CROSS-PROGRAM AREAS

## A. Space Shuttle Program

### Space Shuttle

The year 2001 was one of achievement for the Space Shuttle. There were six successful launches with no significant in-flight anomalies. This visible demonstration of program success and operational safety was due in large part to the diligent, detailed attention of the dedicated NASA and contractor personnel who conduct the ground and onorbit operations of the Space Shuttle system. The Panel commends the Space Shuttle workforce for maintaining a safe and effective program.

There has been progress in incorporating outstanding deviations into Space Shuttle processing work paper. Improvements have also been made in the detailed procedures followed by technicians working on prelaunch activities of the Space Shuttle. However, there is still a large backlog of engineering drawings that have an unacceptably high number of unincorporated drawing changes or Engineering Orders (EOs). These lead to potential misinterpretation of the drawings that can have adverse safety implications (see Finding #11).

The Panel is pleased to note that the first flight of the Space Shuttle Main Engine (SSME) Alternate High-Pressure Fuel Turbopump Alternate Turbopump (HPFTP/AT) took place in 2001. The HPFTP/AT is the final component of the risk-reducing Block II engine safety improvement.

Further SSME safety advances are contemplated from the implementation in the near future of the first phase of the Advanced Health Monitoring System (AHMS), which is intended to reliably shut down the SSME if out-of-tolerance conditions are sensed in flight. A second phase of AHMS has been proposed that would give the engine computer the additional capability to correct specific engine performance, rather than just shutting the engine down when a problem is detected. Unfortunately, this additional phase has been stopped.

The only major component of the SSME that has not been redesigned or upgraded since the start of the Space Shuttle program is the nozzle. The nozzle is an important link in the SSME safety chain. Tube leaks, that can result from impacts with Foreign Object Debris (FOD), cause increased turbine temperatures, which could, if the leak covers several tubes, trigger a premature engine shutdown causing an abort. The nozzle assembly, especially the stacking of the 1,080 tubes and their brazing, requires skilled and experienced practitioners.

At present, the nozzle contractor is in a sustaining production mode, delivering only a single nozzle per year. The Panel is concerned that this level of production cannot preserve the required skill and experience to sustain a long-term program. Consideration should be given to compressing the production of all required nozzles into a shorter period. This would help ensure the availability of critical skills at the contractor.

It should be noted that a more robust nozzle design was considered that is less susceptible to FOD. This channel-wall nozzle, as proposed for the space launch initiative, was considered as a Space Shuttle upgrade, but is not currently funded.

The Electric Auxiliary Power Unit (EAPU) has been reduced from a development program to a technology study due to cost and weight overruns. Of all the proposed orbiter safety

improvements, the EAPU was expected to provide the greatest reduction in risk. The EAPU will be reassessed as a potential safety upgrade by the Space Shuttle program after the technology involved has further matured. In the meantime, the orbiter project is continuing with the established Improved APU initiative that upgrades test equipment, adds instrumentation and hardware protection, and improves fleet leader testing. When completed, this initiative should reduce risk and improve supportability of the currently designed unit. Similar initiatives are at work with the other Space Shuttle elements, such as the solid rocket booster integrated electronics assembly upgrade project. The Panel is pleased to see the initiation of these projects and others with similar risk-reduction and supportability enhancement potential, and encourages their continuation.

Another safety area that the Panel has addressed is the need for a Space Shuttle crew escape system. A satisfactory crew escape system could be a major source of risk reduction if the Space Shuttle is to be flown for an extended number of years. During the last year, NASA has continued to study crew escape options. In addition to the study of crew ejection seats, crew extraction systems, and a crew compartment/capsule escape system, a hybrid system is being studied. This hybrid consists of ejection seats for the commander and pilot, and an escape capsule located in the cargo bay for the remainder of the crew. All these options are still under review.

Although none of the options for crew escape can be funded within the current constraints on the Space Shuttle budget, they must be considered as part of any viable long-range plan that addresses safe human access to space. Because the Space Shuttle does not include a crew escape system, it is below the standards that NASA is currently reviewing in NASA JSC—28354, *Human Rating Requirements*, which will serve as the basis for future space vehicle designs.

The Space Shuttle is acceptable today because of extensive risk-reduction efforts that attempt to obviate the need for a crew escape system. There is a clear need, however, to develop a plan to address the absence of an escape system by either upgrading the Space Shuttle or initiating a program with a realistic timetable to replace it with a vehicle that does meet NASA's new standards.

One way to ensure that the problem is properly acknowledged would be to execute formal documentation of the risk acceptance rationale for the Space Shuttle's lack of a crew escape system. This would identify the deficiency and highlight the fact that the upgrades that have been eliminated and a plan for a more capable eventual replacement are both necessary for minimum safety risk over the full operational life cycle of the Space Shuttle. The Panel believes it is advisable that an appropriately documented technical decision be made to grandfather the current Space Shuttle design.

The Cockpit Avionics Upgrade (CAU), Increment I, will offload tasks from the general purpose computers and produce improved displays on the Multifunction Electronic Display System (MEDS) to enhance situational awareness during ascent, onorbit guidance and navigation, and descent. The CAU System Definition Review has been completed, a brassboard has been built, and approval has been given to go ahead with the system Preliminary Design Review in early 2002.

**Finding 9:** The first increment of the CAU has significant potential for long-term Space Shuttle risk reduction and provides a platform for still further improvements.

**Recommendation 9:** Maintain the previously planned funding to expeditiously implement the CAU.

The intent of redundant wiring in the orbiter is to provide two or more electronic paths for critical functions. The routing of this redundant wiring should be physically separated as well, thereby reducing the risk of simultaneous failures. The wiring inspections of OV-102 (*Columbia*) during its Orbiter Major Maintenance (OMM) period found that this desirable feature was not uniformly applied in the orbiter design. NASA has begun taking remedial actions and plans to upgrade wire routing further during future OMMs.

**Finding 10:** Orbiter wiring inspections have shown instances where redundant wiring is carried in the same wire bundle.

**Recommendation 10:** Expedite efforts to route redundant wires in separate wire runs.

In February 2000, there were 1,500 orbiter drawings with more than 10 outstanding EOs that had not been incorporated into the body of the drawings. Common practice in the aerospace industry limits outstanding EOs to no more than five. Drawings that include large numbers of unincorporated EOs can confuse engineers and technicians trying to interpret them. This is particularly important as employees less experienced with the Space Shuttle are brought into the workforce.

The Space Shuttle program was given an action by the NASA Administrator to develop a plan to correct this situation. As a consequence, KSC identified 175 drawings as having the greatest importance to the work of preparing the orbiter for launch. The 50 thermal protection system (tile) drawings that had the most use at KSC and the highest number of EOs were updated during the year. A pilot program to transfer orbiter drawings to a 3-D format was also proposed but has not been implemented.

Little progress has been made, however, on the remainder of the orbiter drawings, except to prioritize them for incorporating the open EOs. The prioritized list still requires multiple NASA and contractor approvals before the resources will be allocated to incorporate the EOs.

**Finding 11:** Little definitive action has been taken to correct and preclude continuing the undesirable situation of excessive unincorporated EOs in the orbiter engineering drawings.

**Recommendation 11:** Expeditiously reduce the number of the drawing changes currently outstanding.

The status of Space Shuttle logistics is good. There are currently no safety issues, and the relevant supportability metrics are encouraging—a low number of cannibalizations and high percentages of ontime delivery, in-stock availability, and fill rates. This was accomplished in a demanding environment in which the Space Shuttle flew three flights in as many months. Also encouraging is the quality of the hardware. There were few component failures both in flight and during ground test.

However, there are impending long-term issues associated with vendor stability and component and test equipment obsolescence. In addition, stockpiling of commodities with environmental protection restrictions can only meet demands for the short term, as waivers for the future needs of the Space Shuttle program may not be continued. The program is aware of these issues, but it is hampered by inadequate resources. To coordinate the activities needed to maintain an adequate logistics position and in response to independent assessments performed on logistics operations, the program has established a position to integrate the approach to logistics management.

**Finding 12:** Space Shuttle logistics will face increasing challenges from vendor issues including closures, mergers, relocations, and changes in capability.

**Recommendation 12:** Continue to emphasize to all suppliers the importance of timely reporting of all significant business and organizational changes that could affect Space Shuttle logistics.

## Space Shuttle Processing

Effective ground processing of the Space Shuttle at KSC is essential for safe operations. This, in turn, depends on the availability of an appropriately trained, experienced, and motivated workforce, as well as GSE, test gear, and facilities that are in good repair and fully capable of meeting requirements.

In recent years, budget cutbacks have required NASA and its contractors to reduce staffing at KSC. As discussed in previous ASAP Annual Reports, the result was a large reduction in personnel that led to critical skills shortfalls and some safety concerns. In response, NASA adjusted its workforce targets and permitted some hiring to fill specific needs, thereby correcting many of the problems.

Several proposals have recently been made that could impact Space Shuttle processing. First, in an effort to conserve current funding, NASA has proposed postponing the installation of some major modifications, such as MEDS, and performing periodic Structural Inspections (SIs) at KSC, rather than at a contractor's facility in Palmdale, California. The Panel was asked to examine any possible safety implications of this decision to defer Orbiter Major Modifications (OMM) activities and transfer SI and Orbiter Maintenance and Down Period (OMDP) work from Palmdale to KSC. It was concluded that there appeared to be no immediate increase in risk attendant to the plan if all needed wiring and other inspections that would have been done as part of the OMM were added to the SI requirements and the following factors remain equal:

- Safety remains the primary program objective;
- Work is performed according to the same requirements;
- Work paper of equivalent content and quality is used;
- Appropriately trained, managed, and supervised workers conduct the inspections;
- Equivalent test equipment that is appropriately maintained and calibrated is employed; and
- There is equivalent engineering support from the design center.

The transfer of work from Palmdale to KSC would require hiring additional processing workforce to meet the needs of the added OMDP efforts at KSC if the flight rate remains at approximately six per year.

Additional proposals are now being considered to reduce the Space Shuttle flight rate as a further means of conserving resources. If the flight rate is reduced from six to four flights per year and the flights are not unreasonably clustered, there may be no need to acquire additional personnel for the OMDPs. The same engineering and technician workforce could perform both tasks. In fact, the additional work from the OMDPs would provide NASA and contractor managements with some ability to retain critical Space Shuttle processing engineering and technician skills even at the lower flight rate. It is important to realize, however, that

although the work content for in-flow Space Shuttle processing and major maintenance and inspection may be similar, the needed management and planning skills can be quite different. For routine processing, the primary objectives are to roll out a safe and capable vehicle as quickly as possible. Heavy maintenance focuses more on “return to print” and assuring long-term vehicle capabilities. Although OMDPs must also follow schedules, the delivery of a “restored” vehicle capable of many flights (not just the next one) is the primary focus.

**Finding 13:** Deferring the OMMs intensifies the risk that scheduled safety upgrades will never be completed, thereby further increasing the life cycle safety risk of operating the Space Shuttle.

**Recommendation 13:** Incorporate deferred safety-related modifications in the affected orbiters expeditiously. This should not be accomplished at the expense of other safety or operational upgrades, or the prudent maintenance of the Space Shuttle system and its infrastructure.

**Finding 14:** It is reasonable to utilize the same engineering and technician workforce for routine Space Shuttle processing and OMDP work at KSC, since the work content is similar. Planning and management functions, however, differ significantly between line processing and heavy maintenance activities.

**Recommendation 14:** Designate separate, appropriately experienced management teams for the regular processing and OMDP work at KSC. These teams must be well-coordinated, since they will be drawing on the same workforce.

# III. Program Area Findings and Recommendations



- A. SPACE SHUTTLE PROGRAM
- B. INTERNATIONAL SPACE STATION (ISS) AND CREW RETURN VEHICLE (CRV)
- C. AEROSPACE TECHNOLOGY
- D. CROSS-PROGRAM AREAS

## B. International Space Station (ISS) and Crew Return Vehicle (CRV)

As of the end of 2001, the ISS had 15 months of crewed operations. Four “expedition” teams of three astronauts/cosmonauts have carried on the daily operations onorbit under the alternating leadership of American and Russian commanders. The ISS has proven to be well-designed and robust. The crew has been resilient in handling such unexpected problems as the breakdown of two (out of three) command computers in April 2001 (see Cross Program Areas) and a series of “growing pains” with the Space Station Remote Manipulator System (SSRMS). Fortunately, there have been no identified situations that immediately threatened the safety of the crew or the viability of the ISS.

There are apparent differences in the U.S. and Russian approaches to risk management. The U.S. maintains an independent safety organization that oversees ISS operations during an expedition under U.S. leadership. Upon observing or being advised of conditions affecting safety, this organization has the authority to stop or change procedures, and has access to any level of management. The Russian safety organization appears not to have this level of independence and flexibility. During expeditions led by Russian commanders, safety concerns raised by expedition crewmembers appear to take longer to resolve because they must traverse the hierarchical Russian command structure. During the next year, the Panel will look more closely at how the U.S. and Russian safety organizations interact and their level of independence from the normal command hierarchy.

The capability of the ISS Caution and Warning (C&W) system has been a longstanding concern of the Panel. The ISS program has recently completed a comprehensive review and assessment of all aspects of hazard detection and control, from C&W through damage location and control. Based on this study, the ISS seems to be well prepared to handle depressurization, fire hazards, and emergency situations. Some potential improvements, principally in operations and software, have been identified. A management process has been set up to identify, resolve, and close out problems related to this subject. This process has been very well done, though some additional work is needed on techniques for repairing penetrations and for locating fires or penetrations behind equipment racks. While the latter procedures are thorough, they are time consuming and dependent on good oral communications between the crewmembers working at the damage site and those at the ISS C&W panel. These communications could be improved if the crew had a readily available, hands-free intercom system.

Penetration repair capability is currently limited to kits of vacuum putty and two-component epoxy designed for the Space Shuttle program. Since these were designed for short-duration flights with subsequent repair on the ground, it is not clear that these techniques have been qualified as long-term solutions.

ISS plans reflect little emphasis on the case of debris penetration that also results in fire or collateral damage due to the intense energy release at impact. This close proximity of a leak to a fire could well make location of that fire difficult and could enhance combustion by drawing cabin air to the fire site.

**Finding 15:** While the basic framework for system engineering of damage detection, assessment, and control has been established, work remains to be accomplished to reduce vulnerability to the hazards of fire and pressure leaks.

**Recommendation 15a:** Examine procedures, tools, and instrumentation to locate fires and penetrations more rapidly, especially those occurring behind equipment racks.

**Recommendation 15b:** Improve the ability of the crew to communicate with each other while dealing with emergencies.

**Recommendation 15c:** Create, qualify, and stock kits for rapid short- and long-term repair of penetrations.

**Recommendation 15d:** Develop a procedure to be used in the event of combined depressurization and fire.

Currently during certain ISS operations, such as cargo transfer, specific C&W alerts are inhibited by the crew. For example, fire detection warnings are inhibited to prevent false alarms from dust stirred up during equipment movement within the ISS. During the period when these alerts are inhibited, the crew runs the risk that a real alarm situation may arise and no warning will be given. The inhibited alerts must be restored manually to resume normal C&W operation. There is no automatic reminder or reset.

**Finding 16:** There is no visual or aural indication to the crew that safety-related alerts have been inhibited.

**Recommendation 16a:** Develop an appropriate alerting system to remind the crew that C&W functions have been inhibited and/or to enable the crew to limit the inhibit to only a specific period.

**Recommendation 16b:** Avoid the need to inhibit C&W alerts by countering the root causes of false alarms whenever possible.

The ISS program is not planning to carry forward the CRV project to the development and production phases for the next several years. The current favored approach would continue to base the CRV on the X-38 test vehicle. This approach would complete the current atmospheric drop test program and proceed with a space flight test of a prototype X-38, designated V201. A key element of this plan is to reuse the V201 vehicle as the first CRV. After its space flight test, V201 would be stripped down to its basic structure, the interior cabin walls, the moveable flight control surfaces, and the portion of the wiring harnesses that can be reused. All other assemblies and components would be new.

In the meantime, since the Soyuz rescue vehicle can only accommodate three persons, the ISS expedition crews must be limited to that number. Experience over the first year of crewed operations has shown that nearly all of the crew's work time has been spent on assembly, maintenance, and operations tasks, with relatively little time available for scientific experiments.

The ISS assembly program is planned to continue for several more years. As assembly wanes, maintenance workload will grow—due to a broadened equipment suite and the aging of the entire ISS. Simultaneously, more time will be desired for onboard science. This raises the very

real possibility that the crew will not be able to perform all the required tasks without impacting crew health, safety, and/or performance.

**Finding 17:** With the decision to scale back the production contract for CRVs, the ISS must operate for the foreseeable future with a crew limited to three.

**Recommendation 17a:** Continue the flight test program for the X-38 and proceed to the space test of the V201 prototype.

**Recommendation 17b:** Press to restore the CRV production program or find a substitute rescue vehicle approach to permit expansion of the ISS crew.

Over the last several decades, NASA has led an international effort to understand how the space environment is impacted by the presence of Micrometeoroid/Orbital Debris (MMOD). This work has led to a detailed characterization of the size and number of debris objects in the near-Earth space populated by satellites. It also has provided a growing ability to track such objects and to maneuver spacecraft, including the Space Shuttle and ISS, to avoid collisions.

The ability to monitor and model this dynamic environment and to specify the size and characteristics of suitable shielding depends on the availability of the core MMOD group at the Johnson Space Center (JSC) who have, over the years, led the effort to understand the environment and to form international agreements to limit breakups and other sources of debris. Proposed budget cutbacks would eliminate funding for the activities of this JSC MMOD group. This would deprive the Space Shuttle and ISS programs of updated knowledge on debris risks.

**Finding 18:** Funding cuts threaten to eliminate all effort on maintaining and updating surveillance and modeling of the orbital debris population as early as October 2002.

**Recommendation 18:** Reexamine the decision to eliminate this important function and assure that the core MMOD effort is continued.

### III. Program Area Findings and Recommendations



- A. SPACE SHUTTLE PROGRAM
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## C. Aerospace Technology

This year saw a continued transition in the Aerospace Technology Enterprise from the evolutionary development of conventional aeronautical technology to a focus on more revolutionary technologies that will make possible truly advanced aerospace vehicles. This is especially evident at the Langley Research Center (LaRC), where new initiatives, such as biologically inspired metallic structures, electrostrictive polymer actuators, and nanoscale fabrication techniques are being pursued.

In the area of safety research, the Panel was encouraged to see real progress in NASA's Aviation Safety Program (AvSP), a multi-Center effort that is aimed at accident prevention, accident mitigation, and aviation system modeling to identify and correct system problems before they lead to accidents. Although conceptually well-founded, the AvSP appears underfunded to accomplish its primary objectives. Recent aviation safety problems suggest that efforts, such as the development of better methods for nondestructive evaluation of composite structure, warrant a greater emphasis from the Country's preeminent aeronautical research organization.

Another new safety effort in the Aerospace Technology Enterprise is the Aviation System Technology Advanced Research (AvSTAR) initiative. The goals of this initiative are to accelerate the development of selected NASA air traffic management technologies that have been identified by industry and the Federal Aviation Administration (FAA) to improve the capacity and reliability of the current system over the next several years, and to provide the basic research and long-term exploratory investigations for the air transportation system of the future. The Panel noted that there appears to be a much improved working relationship between NASA and the FAA on the AvSTAR effort, with clear understanding that any new technologies and new concepts will have to be introduced gradually and managed very carefully to not only maintain but improve the level of safety within the system.

The Small Aircraft Transportation System program has goals for improving the operational mobility and safety of smaller general aviation aircraft. The Panel is encouraged by the inclusion in the program of numerous partners who bring strong industry experience and insight into the safety aspects of this program.

One of the disturbing aspects of the safety effort within the Aerospace Technology Enterprise has been the damage or loss of several high-value assets during the past year. Fortunately, there have not been any injuries associated with these mishaps. A formal MIB was convened for each of these incidents, and the Panel has followed the activities of each of the MIBs. When final reports are issued for these mishap investigations, the Panel will review them for possible systemic causal or contributing factors. The MIB process itself, however, appears worthy of some improvements. These were covered in Section II, since they are issues that go beyond Aerospace Technology.

The Panel has continued to monitor the development of flight operations procedures for the Stratospheric Observatory for Infrared Astronomy (SOFIA) and is encouraged with the progress made in identifying experienced personnel from United Airlines, the subcontractor for SOFIA flight operations, to undertake this development. However, with the recent program stretch-out, this essential planning effort has been postponed. The Panel urges the SOFIA program to resume this important effort as soon as possible and to ensure that there is a continuity of experience despite the delays.

### III. Program Area Findings and Recommendations



- A. SPACE SHUTTLE PROGRAM
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## D. Cross-Program Areas

### Computer Hardware/Software

Reliance on computers and software to support and control many of NASA's large and complex systems has become common. The safe operation of these systems depends on hardware and software that have been designed, built, and tested to satisfy exacting requirements, and to meet the highest standards of safety to protect humans and valuable assets in space and on the ground. The events of September 11 were a chilling reminder that operating these systems safely is not the only concern. NASA must be equally vigilant to ensure the security of these systems.

Throughout the past three years, the Panel has focused on the security of the ISS computer and communication systems of the many support systems on the ground and of the new systems under development, such as the Checkout and Launch Control System. NASA has made great strides in implementing technologies and practices that should keep these computer systems secure. NASA has established an excellent standard, the required culture, and the necessary processes to have a high likelihood of protecting against the ever-evolving art of cyberspace pirates. The Panel will continue its focus on computer security throughout the next year. This focus must not diminish the pivotal activities required to review software safety for NASA's ongoing computer system development efforts.

In late April, the Command and Data Handling (C&DH) computers onboard the ISS were totally out of operation for an extended period, due to a design problem that led to a failure in the Mass Storage Devices (MSDs) for two of the three command and control computers. The Space Shuttle was docked to the ISS when this occurred, and its systems assumed most of the responsibilities of these computers. Had the Space Shuttle not been docked, control could have been turned over to the Russian segment of the ISS, which can provide backup for most of the critical C&DH functions in the event of such a failure.

In addition, the C&DH design and architecture were found to be vulnerable to instability from task overload, particularly when the SSRMS is being used. The ISS has developed operational guidelines that control this problem. This is an acceptable mode of operation during the construction of the ISS, but is not adequate for conducting scientific research in a production environment in which many activities execute concurrently.

One Panel member participated in the Independent Review Team that was initiated to investigate these failures. Intensive analyses were conducted by the team during the four months after the event to determine the root causes and to implement safeguards to prevent the recurrence of the problem. As a result of the team's preliminary findings, the deployment schedule for Solid State Mass Memory Units (SSMMUs) to replace the MSDs was accelerated. These SSMMUs are expected to be highly reliable, are already onboard the ISS, and are scheduled to be installed in all the computers by early 2002.

Following this activity, the Panel was asked by the Administrator to conduct an assessment of NASA's redundancy approach for the ISS computer systems. The Panel determined that the ISS approach is consistent with the best practices used by other organizations that rely on high-availability computer systems to support human safety and to protect high-value assets. A recommendation was made to conduct a periodic review of the C&DH design. One of the

Panel members is participating on the team that is conducting the first of these reviews. Following this assessment, NASA has also developed a plan to conduct an annual conference to highlight and to share new techniques and technologies for achieving ultra-highly reliable systems among Government, industry, and academia.

The safe operations of NASA's major systems have long required significant attention to computer security. Keeping ahead of advancing techniques of electronic intrusion will continue to be a daunting task. The cracking of the Data Encryption System (DES)—a 56-bit encryption code certified by the National Institute of Standards and Technology in 1998—is but one example of the changing threats engendered by new discoveries and advancing technologies. In light of the vulnerability of DES, the ISS program has made plans to upgrade command uplink encryption from DES to a triple DES approach that employs three 56-bit encryption keys. Ensuring the security of computer systems and the integrity of the software and data that are a part of these systems will require enhanced tools, thorough training, and a commitment to maintaining a constant vigil on an ever-changing target.

**Finding 19:** The terrorist attacks on September 11 emphasized the need for increased security of all national assets, including NASA's computer systems. Since many of these systems safeguard the lives of astronauts and cosmonauts and the safety of valuable international assets, it is crucial that security vulnerabilities be fully understood and closely managed.

**Recommendation 19a:** Accelerate the schedule of penetration exercises to gain greater insights into computer security vulnerabilities; determine if further threat analysis should be conducted; review all vulnerabilities; and ensure that plans are adequately formulated to mitigate these vulnerabilities and that work is proceeding to prevent critical systems from being compromised.

**Recommendation 19b:** Accelerate the schedule for the implementation of triple DES.

**Finding 20:** The C&DH system is vulnerable to instability under heavy load conditions. This problem is currently handled by procedurally controlling processing activities.

**Recommendation 20a:** Gain an improved understanding of the range of commanding problems that lead to constraints on the system. Issue additional Problem Reports (PRs) as appropriate.

**Recommendation 20b:** Process outstanding PRs.

**Recommendation 20c:** Evaluate potential architectures that would improve system stability and robustness and ensure safe operations. Implement architecture improvements as soon as it is prudent to do so.

## Extravehicular Activity (EVA)

The EVA program has initiated a paradigm shift to overcome the significant challenges faced with the upcoming “wall of EVA” for ISS. This shift includes an array of changes that if implemented in unison require less hardware, testing, and ground processing resulting in minimal additional program risk and significant savings. None of the changes results in additional safety risk. In addition, the program has taken advantage of much research originally intended for a follow-on suit, to develop upgrades to the current suit. This has extended the life of a suit

which was originally designed a quarter of a century ago. As a result of these actions, the current EVA program is in good shape. However, there is no significant research directed at future improvements and no planned replacement for the current suit.

## Crew and Occupational Health

This year, the Panel has increased its activities related to crew health because of the importance of this subject to the successful long-term occupancy of ISS. The area of radiation protection was also incorporated with crew health. As the year drew to a close, worries about bioterrorism prompted a look at NASA's activities in occupational health. Reviews were conducted of life science research and medical operations at JSC and KSC.

### Medical Operations

Space flight operations have undergone a dramatic change with the ISS coming online. A single NASA organization is responsible for ISS and Space Shuttle crew health. With the addition of ISS, more civil service flight surgeons have been added, and the Crew Health Care System hardware is now flying aboard the ISS. In addition, this organization provides support to the Mission Control Centers in Houston, and contractor physicians are deployed to Russia.

There are two main boards that set policy for joint medical operations, the Multilateral Medical Operations Panel and the Multilateral Space Medicine Board. Together they support medical reviews, crew health, crew and physician certification, and any other medical issues that may arise. NASA Headquarters provides oversight and approves and sets policies for medical operations through the Multilateral Medical Policy Board. For crew selection, the International Partners have developed a "core set" of medical requirements or standards. Although most of the agencies have their own requirements, each astronaut candidate must meet the core set before they are accepted into the Astronaut Corps. In general, the system has worked well in providing for crew health.

### Prebreathe Protocol for Extravehicular Activity

For several years, the Panel has followed the activities to develop a shorter prebreathe protocol for EVAs. One of the concerns about shortening the time during which the astronauts breathe pure oxygen at lowered pressure arises from the risks associated with Patent Foramen Ovale (PFO). For many years, there has been an ongoing debate in the medical community regarding the risk of PFO. Twenty to 30 percent of the population has a congenital defect in their heart (where the four separate chambers of the heart fuse into a single organ during fetal development, and sometimes a small hole is left between the main atria of the heart). This slight defect is called a PFO. This usually presents no problem for most people, except during times of extreme stress. During space missions, the most vulnerable time is during EVA. As crewmembers are exposed to decreasing suit pressures during the EVA, bubbles can develop within the circulatory system. When these bubbles reach the heart, they can pass from the right side to the left side of the heart and migrate to the brain. There they can result in an air embolus and stroke.

NASA recently commissioned a committee to evaluate the risk of PFO in astronauts in space. They recommended not to incorporate additional PFO screening for selection and retention standards because the risk is low.

### Radiation Monitoring on ISS

There are “large uncertainties” in the projection of the risks of the effects from space radiation. This is due to limited monitoring capabilities in flight, the impact of the ratio of ground vs. space radiation exposure, and the relatively small number of subjects for analysis. All of this translates into continued questions about the long-term impact of radiation exposure and risks, especially cancer.

Despite the prevailing questions, there is mounting evidence that the risk of cataracts in crew exposed to higher levels of radiation is increased. Data indicate that the most risk is to crews exposed to high-inclination orbits. There is a need for more research in this critical area, as already recognized by the National Academy of Science in 1997 and the National Council of Radiation Protection and Measurement in 2000. There are preliminary radiation exposure limits in place for ISS. However, given the uncertainties of onorbit measurement systems and the consequences of radiation exposure, particularly the late effects of heavy ions, additional effort is needed to better define safe protocols. Thus, radiation remains a serious risk for ISS flight crews. The Panel will discuss with NASA the advisability of securing improved radiation detectors and setting more stringent lifetime dose limits for crews.

In regards to the risk mitigation efforts for ISS, there is an important research project examining the material used for shielding the crew. This study compared aluminum and polyethylene as a shield against Galactic Cosmic Rays (GCRs). Using an active tissue equivalent proportional counter, polyethylene proved to be a very effective absorber of GCR. Based on this study, a detailed supplemental objective was conducted on ISS and found that a 20 percent reduction in radiation exposure in the sleep station could be achieved by polyethylene shielding used in conjunction with water stored in transfer bags. The Panel intends to explore with NASA the feasibility of implementing this shielding for the ISS. Given the uncertainty of the long-term effects of radiation on flight crews, it is prudent to take all steps necessary to protect the health of the crew.

### Psychosocial Support

To maintain safe operations onboard ISS, it is important to ensure that astronauts, cosmonauts, and flight controllers are receiving the best available training in human dynamics so they are fully prepared to cope and deal with behavioral issues.

Astronaut candidates receive several briefings to familiarize them with the basics of Japanese, Russian, and other cultures. When astronauts are selected, but before they are assigned, they receive individual assessments, teamwork and group living seminars, and more leadership and cross-cultural training. When they are selected for the Expedition Corps, they receive 7–10 days of training focusing on leadership. This training is designed to help individuals understand their strengths and limitations, and to self-manage their skill training and personal development. Crew resource management and special Space Shuttle and ISS training are also

part of the curriculum. Currently, this training does not include peer feedback, which has been shown to be beneficial in other group dynamic situations.

Unfortunately, the U.S. program is not fully integrated with the Russian program. The Russians conduct similar training, but integrating the two would provide significant benefit, as well as an opportunity for more training together. NASA should continue to work toward integration of the two programs.

One of the main safety and health issues is crew fatigue. Astronauts and cosmonauts work hard and have a strong compulsion to complete tasks within allotted timelines. Scheduled tasks combine with the demands of scientists, engineers, and managers on the ground to overwork crews. Signature approval by the flight surgeon is not required on the mission timeline. Such approval authority would allow the flight surgeon to better manage crew health.

### Occupational Health Program

In 1996, NASA Headquarters (HQ) transferred to KSC the responsibility for the implementation of the NASA Occupational Health Program through a Memorandum of Understanding (MOU). The Panel's Crew and Occupation Health team will review the plans, operations, and interfaces of this program.

Notably, in response to the events of September 11, NASA contracted for the development of a course on bioterrorism called "Medical Aspects of Biological, Chemical, and Nuclear Agents of Terrorism." This course has been used to train personnel throughout the Agency on bioterrorism.

## IV. Appendices



# Appendix A

## Aerospace Safety Advisory Panel Membership

### CHAIRMAN

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### DEPUTY CHAIRMAN

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NASA Kennedy Space Center

MR. SIDNEY M. GUTIERREZ  
Director, Monitoring Systems and  
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USN (Ret.)  
President and Chief Operating Officer  
Metro Machine Corporation  
Former Commander in Chief,  
U.S. Atlantic Fleet

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Director, Research and Development,  
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Associate Professor, Computer Science  
and Engineering (Courtesy)  
University of Nebraska - Lincoln

## EX-OFFICIO MEMBER

MR. FREDERICK D. GREGORY  
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MR. DAVID M. LENGYEL  
Executive Director  
NASA Headquarters

MS. SUSAN M. BURCH  
Staff Assistant  
NASA Headquarters

MS. VICKIE B. SMITH  
Secretary  
NASA Headquarters

# Appendix B

## NASA Response to Annual Report for 2000

### Summary

NASA responded on May 24, 2001, to the “Findings and Recommendations” from the Annual Report for 2000. NASA’s response to each report item is categorized by the Panel as “open, continuing, or closed.” Open items are those on which the Panel differs with the NASA response in one or more respects. They are typically addressed by a new finding, recommendation, or observation in this report. Continuing items involve concerns that are an inherent part of NASA operations or have not progressed sufficiently to permit a final determination by the Panel. These will remain a focus of the Panel’s activities during 2002. Items considered answered adequately are deemed closed.

Based on the Panel’s review of the NASA response and the information gathered during the 2001 period, the status of the recommendations made in the Annual Report for 2000 is presented after each of NASA’s responses.

National Aeronautics and  
Space Administration  
**Office of the Administrator**  
Washington, DC 20546-0001



MAY 24 2001

Mr. Richard D. Blomberg  
Chairman  
Aerospace Safety Advisory Panel  
110 Lenox Avenue  
Stamford, CT 06906-2300

Dear Mr. Blomberg:

In accordance with your request after our February 8, 2001, meeting, enclosed is NASA's response to Section II, "Findings and Recommendations," from the Aerospace Safety Advisory Panel (ASAP) Annual Report for 2000.

The ASAP's efforts in assisting NASA to maintain the highest possible safety standards are commendable. Your recommendations are highly regarded and continue to play an important role in risk reduction in NASA programs.

We thank you and your Panel members and consultants for your valuable contributions. ASAP recommendations receive the full attention of NASA senior management.

We welcome the continuance of this beneficial working relationship with the Panel.

Sincerely,

A handwritten signature in black ink, appearing to read "Daniel S. Goldin". The signature is fluid and cursive, with the first name "Daniel" being the most prominent.

Daniel S. Goldin  
Administrator

Enclosure

# 2001 Aerospace Safety Advisory Panel (ASAP) Report

## Findings, Recommendations, and Responses

### Finding #1

The current planning horizon for the Space Shuttle does not afford opportunity for safety improvements that will be needed in the years beyond that horizon.

### Recommendation #1

Extend the planning horizon to cover a Space Shuttle life that matches a realistic design, development, and flight qualification schedule for an alternative human-rated launch vehicle.

### Response

Code M - Concur: It is prudent to assume that the Shuttle will continue to support human space flight well beyond the current planning date of 2012, probably at least until 2020. Industry and NASA studies indicate that there will not be a compelling case for funding, developing and certifying a Shuttle replacement system for human space flight until late in the next decade. Therefore, NASA is actively assessing further safety improvements, beyond the current suite of planned and funded upgrades, which may be implemented in the Shuttle within the next 5-7 years and which could significantly reduce the operational risk of the Shuttle for many years of continued operations.

### Status

**Open.** NASA's response is good but has been negated by external constraints.

## Finding #2

There is no in-flight crew escape system for the Orbiter other than for abort below 20,000 feet during a controlled glide.

## Recommendation #2

Complete the ongoing studies of crew escape design options and implement an improved system as soon as possible.

## Response

Code M - Concur: The Space Shuttle Program (SSP) concurs with the recommendation and is investigating enhanced crew escape capability with the objective of making significant strides in reducing crew risk for vehicle failures, which result in the loss of the orbiter vehicle. A Crew Escape Study has been initiated to reexamine Space Shuttle crew escape options.

## Status

**Continuing.** Several schemes have been studied, but no recommendation has been made.

### Finding #3

Redundant hydraulic lines for the three orbiter hydraulic systems are not adequately separated to preclude loss of all hydraulic power in the event of a single catastrophic failure of adjacent hardware.

### Recommendation #3

Provide the same degree of separation of redundant critical hydraulic lines as is given to redundant critical electrical wiring.

### Response

Code M - Concur: Orbiter hydraulic systems utilize and will continue to implement the same considerations and degree of redundant system separation as is given redundant critical electrical wiring. Primary consideration is system placement such that a single catastrophic failure environment does not exist. Emphasis is placed on precluding events that may propagate from one function to another. Hazards associated with arc tracking can propagate to another wire in close proximity and therefore have influenced electrical wiring physical separation requirements. Hydraulic line hazards such as leakage or rupture cannot propagate to an adjacent hydraulic line. Extensive Failure Modes and Effects Analysis / Critical Items List (FMEA/CIL) and Hazard Analyses of the Orbiter systems and operational environment have not identified any credible single failure modes which would result in the loss of hydraulic power. Neither system is protected against extreme externally induced events such as those that DOD separation requirements address.

### Status

**Closed.** NASA reported that they have evaluated the arrangement and are satisfied that it is OK.

## Finding #4

The ongoing effort to improve the work paper used at KSC by incorporating outstanding deviations and clarifying and simplifying the work instructions is proceeding well. Some lesser effort has been focused on improving the vehicle engineering drawings and reducing the engineering orders (EOs) they contain.

## Recommendation #4

- 4a. Continue vigorous efforts to upgrade the work paper, even as the flight rate increases, in order to maintain the positive momentum that this worthwhile initiative has generated.
- 4b. Focus additional effort on updating vehicle engineering drawings with the objectives of incorporating as many EOs as possible and assuring the clarity of all information.

## Response

- 4a. Code M - Concur: Upgrading the paperwork continues to be a primary strategic initiative. The implementation of enhancements aimed at “work paper “Deviation” reduction continues to show positive results. The IPP (Intranet Provided Procedures) has enabled the technician to select and work paper that has been pre-approved by engineering, and other initiatives such as MAXIMO are moving processing toward a more paperless work environment. All these initiatives combine to continue vigorous upgrade to the work paper quality while reducing the labor to achieve these gains.

## Status

**Continuing.** Being aggressively worked with good progress.

- 4b. Code M - Concur: Each SSP project has configuration control to minimize the number of EOs before engineering drawings are updated. Additional focus will be implemented on improving engineering drawings. For example, the tile drawings, which are complex high-use drawings, have been updated to incorporate their EOs and this process will be applied to other highly complex, high-use drawings on the vehicle. Additionally, the Space Shuttle Program is embarking upon a one-year pilot program to convert orbiter vehicle 2D drawings to 3D digital drawings which if implemented would incorporate all of the outstanding EOs.

## Status

**Continuing.** NASA agrees with the problem but little remedial action has been taken.

## Finding #5

The KSC facilities, ground support equipment, and test and checkout gear to support Space Shuttle processing and launch operations continue to age. The status of the potential readiness of these essential assets has been projected, but there is no detailed, funded plan to ensure that this aging infrastructure can safely support the Space Shuttle for its likely operational life.

## Recommendation #5

Develop a detailed plan and budget to maintain and upgrade the KSC assets that are essential to the safe operation of the Space Shuttle for its reasonably expected flight life so that an appropriate infrastructure life extension program can be implemented.

## Response

Code M - Concur: Infrastructure support and upgrades requirements for the KSC facilities, ground support equipment, and test and checkout equipment are well defined and are updated yearly. The SSP initiated an Infrastructure Revitalization Team to develop a detailed plan to upgrade the infrastructure at all element sites, in addition to KSC, for identified life through at least 2012. Infrastructure remains a top program initiative and significant investment is needed. Since there were no new initiatives funded from the FY 02 budget process, other programs within Human Space Flight are being considered to support infrastructure requirements.

## Status

**Continuing.** NASA understands the issue and is working it.

## Finding #6

Due to the rapid pace of ISS assembly launches and the many and varied resulting configurations, Multi-Element Integration Testing (MEIT) with operational loads of Portable Computer System (PCS) software is limited and, in some cases, may only be accomplished in the brief time allocated for regression testing.

## Recommendation #6

Strive to accelerate scheduled releases for PCS software. Be prepared to delay schedule, if necessary, to assure that MEIT testing and astronaut training with the flight loads of PCS software are thorough and complete.

## Response

Code M - Concur: Every attempt is made to accelerate software releases where it can be done safely. For each test (MEIT, Stage, etc.), every effort will be made to ensure that the software is consistent with the requirements for the test. Schedules will be delayed where necessary to ensure that all necessary testing and training is conducted prior to launch.

## Status

**Closed.** A satisfactory response.

## Finding #7

The specific definition of many of the tests identified in the draft X-38 (V201) Space Flight Test Plan appears to be lagging. The return from orbit test specified by this plan is the final planned validation of the X-38 vehicle and derived CRV.

## Recommendation #7

Establish a timetable for the early completion of the detailed X-38 (V201) Space Flight Test Plan. Sufficient time must be made available for a thorough review process and for possible changes in the plan resulting from the review.

## Response

Code M - Concur: A draft X-38 (201) Space Test Plan has been written and has been made available to the ASAP. The plan will be matched with mission planning efforts and must involve the yet to be identified CRV Phase 1 contractors. The X-38 Space Test Plan is scheduled to be released for final review at Launch-15 months, with a final baseline planned for Launch-12 months. This schedule will allow full participation of the Phase 1 contractors in the final flight test plan and provides sufficient time for review as well as for incorporation of changes.

## Status

**Closed.** A satisfactory response.

## Finding #8

Because of the innovative processes used, there is some possibility that all of the design knowledge related to safety issues that has been acquired by the NASA X-38 team may not be transferred to the contractor selected to build the operational CRV.

## Recommendation #8

Develop a plan to ensure that all of the design experience gained by NASA in the X-38 technology validation effort is transferred to the contractor selected to produce the operational CRV.

## Response

Code M - Concur: The X-38/CRV project recognizes that the transfer of the X-38 experience to the CRV contractor is critical to the success of the CRV project. A plan to ensure that the design experience gained by NASA in the X-38 technology validation effort is transferred to the contractor is already in place and is captured in the contractor's CRV Phase 1 Statement of Work and in the government's plan for managing the CRV contractors. The CRV program is prepared to brief the ASAP regarding the specifics of this plan.

## Status

**Closed.** A satisfactory response.

## Finding #9

The overall ARC flight operations, including the Stratospheric Observatory for Infrared Astronomy (SOFIA) science program management communication and coordination, have improved significantly but still merit close management oversight with specific attention to early and continuous integration of flight operations personnel into the project.

## Recommendation #9

ARC flight operations personnel should continue to increase their cognizance of the aircraft modification activities to insure timely coordination and implementation of flight operations requirements.

## Response

Code S - Concur: The Office of Space Science concurs with the recommendation and is pleased that the ASAP report reflects recognition of the significant actions that have been taken to involve flight personnel in the SOFIA program. The following specific items were briefed to the ASAP on July 25, 2000 at the ARC:

- The position of SOFIA Deputy Program Manager for Flight Operations was funded and filled by a senior level pilot and aviation manager with commercial and military experience. This position reports directly to the ARC Director for SOFIA-related aviation matters as well as providing oversight for flight operations development.
- Various NASA/contractor teams with flight crew personnel actively contribute to both development and operations planning for SOFIA. These include the operations Integrated Product Team (IPT) and working group (aircraft and observatory), the cockpit working group, and the crew station working group.
- The recognition of the importance of having experienced flight crew personnel participate in planning and development was highlighted by identifying the individuals with such expertise already on the SOFIA NASA/contractor team. The ARC SOFIA project and program managers are also supported by a full time consultant with over thirty years of engineering test and research pilot experience with NASA. (Subsequent to the July ASAP briefing, United Airlines assigned their B747 Fleet Manager to manage SOFIA operations support).
- Close coordination with the ARC Aviation Management Office and Airworthiness and Flight Safety Review Board for timely input and review was also noted.

In direct response to ASAP recommendation #9, the ARC Director will continue to ensure that ARC flight operations personnel and their input are effectively utilized in development and operations planning for the SOFIA program.

## Status

**Closed.** NASA's response and related actions are satisfactory.

## Finding #10

Not all Aviation Safety Officers (ASOs) report directly to their Center Directors.

## Recommendation #10

ASOs should report directly to their Center Directors.

## Response

Code J – Nonconcur: NPG 7900.3A stipulates that the ASO be appointed by the Center Director or designee, and acts on behalf of the Center Director when discharging the duties of ASO. It also requires Aviation Safety Officers to be on flight status and current in assigned aircraft, so they are more expert in the current mission and better understand the risks involved. Since most ASOs are also line pilots, it is more efficient that the work directly for the senior aviation manager responsible for risk management (e.g. Chief, Aircraft Branch). However, the NPG also assigns them the authority to take safety issues “to a higher level of management.” This is interpreted to mean that even though they work for the senior aviation manager, they have a direct line of communication to the Center Director on aviation safety issues, and that this link should be formally represented on the Center’s organization chart (usually as a dotted line from the ASO to the Center Director). The NPG uses the term “higher level of management” instead of “Center Director” to permit the ASO to raise issue to HQ level without attribution, if necessary.

The Office of Management Systems believes that existing policies and current practices satisfy Recommendation #10 that states “ASOs should report directly to their Center Directors.”

Code R: Code R fully supports the positions of the Ames, Glenn, Dryden and Langley Center Directors that their respective ASO’s have direct access, and that organizational placement is based on multiple factors, including the ability to maintain a working-level cognizance on aviation safety matters. While the Panel’s concern that independence in reporting safety problems can be compromised by the ASO’s being organizationally removed from the Center Director is understandable, Code R believes each Center has sound processes and multiple safeguards to ensure that not only the ASO’s, but other personnel can easily elevate safety issues.

## Status

**Continuing.** The Panel is disappointed that neither Code J nor Code R concur with this finding and recommendation. The reliance on informal or “dotted line” reporting of the Center Aviation Safety Officers to the Center Director certainly weakens the position of the Safety Officer and sends the wrong safety message to the rest of the organization.

## Finding #11

The critical skills challenge faced by NASA and its contractors in the Space Shuttle and ISS programs continues despite resumption of active recruiting of experienced and new employees.

## Recommendation #11

Provide more effective incentives to retain employees with critical skills in such areas as Information Technology and Electrical/Electronic Engineering. Continue active recruiting of experienced and “fresh-out” employees, using appropriate incentives when necessary.

## Response

Code M - Concur: Both NASA and its contractor management teams have recognized the challenges of competing for critical skills in today’s work environment, and have begun focused development of organizational assessment programs with emphasis on skills maintenance. These programs are targeted to include multiple tools and approaches (such as pay incentives, cross training, mentoring, formal career development planning, etc) to maintain the appropriate balance of experienced skills as well as a continuous revitalization through the steady introduction of recent graduates. NASA has established fresh out goals at OSF Centers, used recruitment or relocation (signing) bonuses when necessary to attract quality hires at all levels, and authorized the payment of more competitive salaries in critical skill areas.

## Status

**Continuing.** The critical skills maintenance activities appear well founded.

## Finding #12

NASA's recent hiring of inexperienced personnel, along with continuing shortages of experienced, highly-skilled workers, has produced the challenge of training and integrating employees into organizations that are highly pressured by the expanded Space Shuttle flight rates associated with the ISS. There is no systematic effort to capture the knowledge of experience personnel before they leave. Stress levels within the workforce are a continuing concern.

### Recommendation #12a-e

- a. Provide active mentoring and other career development incentives to bring new employees to full productivity as rapidly as can be accomplished with safety remaining paramount. Expand resources and delivery methods available to Agency level training programs to enable greater participation at Center and program levels.
- b. Continue efforts, in partnership with NASA contractors, where appropriate, to provide hands-on experience.
- c. Establish processes that capture the knowledge of experience personnel before they leave or retire.
- d. Help employees deal positively with work-related stress.
- e. Implement an evaluation of the processes used to develop new hires into productive members of the workforce.

### Response #12a-e

Code M – Concur: NASA and its contractors have made significant enhancements in the employee training and development arena. NASA civil servants now have individual career development plans tailored to meet their specific needs, including both hands on experience and appropriate training and education. Significant emphasis has also been placed on employee development with an Agency wide Leadership Development Initiative, a more systematized mentoring program, and increased usage of computer based training. The need to monitor stress levels and provide coping strategies has received considerable attention in all organizations, with significant progress made in this area. NASA has also recognized the importance of capturing the corporate knowledge in our aging workforce and transferring it to the next generation.

Code F – General Response: NASA concurs with the recommendation(s). NASA and its contractors have made significant enhancements in the employee training and development arena. Several NASA Centers have implemented individual career development plans for their workforce, or for specific segments and occupational categories. These workplans enable management and employees to plan and implement formal training initiatives, career development assignments, and job rotations which enhance current and future performance. Many Centers have also examined their need for leadership development, and have implemented new training initiatives designed to address these needs and requirements. More systematized mentoring programs and increased usage of computerized training have been implemented within the

Agency. The need to monitor stress levels and provide coping strategies has also received increased attention across the Agency, with significant progress being made in this area.

Code F – 12a: NASA concurs with the recommendation. As a result of beginning to hire new employees and fresh-outs, the NASA Centers have instituted, or have begun to revitalize, various orientation and other training programs designed to assimilate new employees into the workforce and provide mentoring and career development guidance. Many programs also include the requirement for specific types of training (e.g., technical or administrative), and include both on-the-job and developmental experiences over a period of time. Components in many Centers' training programs also provide for guidance to supervisors in designing a training plan or individual development plan, providing mentoring and coaching, and evaluating work products and progress. The goals of these programs are to aid in the smooth and effective integration of new employees into the Center and Agency workforce by: providing a continuing and accelerated learning process; providing employees a way of identifying with the Center by understanding its mission and values; providing interaction with more senior staff and leaders; and providing opportunities to develop relationships with peers. At the Agency level, efforts are being initiated to establish a network of experienced practitioners who can provide mentoring and access to expertise in project management.

At the Agency level, resources have been requested to enable NASA to expand the delivery methods being utilized to develop the workforce. Specific emphasis will be placed on the development of e-learning alternatives that can be accessed at all locations and levels, and increasing the ability to expand participation levels across the Agency. In addition, new capabilities are being developed to facilitate learning within intact teams, delivering tailored content directly to a project team at the point in time specific training is needed. In addition, some Centers have also increased their resources available for training, and are instituting Center specific initiatives based upon Center needs. In addition, learning organization tools and methods being introduced in pilot projects within NASA are increasing organizational understanding, motivation, buy-in, and results. Examples of new initiatives include web-based course delivery and partnerships with universities for academic training.

Code F – 12b: NASA concurs with the recommendation, and a primary emphasis in developing the workforce will continue to be reliance on valuable on-the-job experience. In addition, the NASA Academy of Program and Project Leadership is in the process or revising its career model to enable an expansion of the identification of experiential development. NASA's Professional Development Program also provides a combination of formal training, briefings, and developmental assignments within and outside the Agency.

Code F – 12c: NASA concurs with the recommendation. Several efforts are underway to more effectively capture the "lessons learned" from experienced personnel nearing or at retirement. In addition, the NASA Academy of Program and Project Leadership has initiated a series of "Knowledge Sharing" forums and has initiated an area on its website for knowledge sharing and lessons learned. An emphasis is being placed on making maximum use and sharing of the experience of employees and managers both while they are still at NASA and after their retirement. Various avenues are being explored for access to this expertise both within NASA and gaining access to the knowledge base of those who leave the Agency. With regard to sharing knowledge within the Agency, NASA has also revised its Fellowship program to include a planned reentry requirement. The reentry plan requires individuals returning from longer-term University programs to identify with their management how their new learning will be shared within the Agency and how it will be applied strategically.

12d – Code AM: The NASA Employee Assistance Program (EAP) a voluntary element within the overall Occupational Health Program whereby employees can receive professional counseling for multiple problems is aggressively marketed to all employees. EAP utilization, a mark of employee confidence, increased by 31.3% between 1997 and 2000 despite an approximate 10% decrease in the base population.

In early 1998, after monitoring EAP utilization, additional resources and training were provided to all NASA Centers. This training was designed to enhance the skills of the EAP counselors, personnel officers, and equal opportunity representatives who serve as front line resources for employees dealing with stress. The training was repeated upon request as a number of NASA Centers the following year.

In 2000, to further augment available resources, a 24-hour EAP Hot Line was established through the Minnesota After-Hours Crisis Connection complementing the earlier addition of a 24-hour Telephone Depression Screening Survey. Other positive actions include the development of a web-based training for supervisors on how to identify and manage stressed employees. Another web-based module was developed specifically to assist individual employees in managing personal stress and a third module expanding on EAP services is under development. The Occupational Health Program has contracted for the development of a survey instrument to assess pre- and post-intervention methods for stress reduction. Regular, periodic Information on mental and physical health practices are posted on NASA's award-winning occupational health web site at <http://ohp.nasa.gov/>. In October, at the first meeting of NASA's new Health Council, the Administrator directed that each Center Director send a communication to each employee and their family. This communication was sent to employees at home reminding them of the myriad of health programs available, including EAP and encouraging them to freely participate.

And finally, to ensure the professional competency of those providing EAP services, continuing education is provided through the Annual Occupational Health Conference, periodic ViTS, and support of other professional training opportunities.

Code F – 12c: NASA concurs with the recommendation. Centers will be evaluating systems and processes for developing their new hires, assimilating them into the workforce and sharing best practices.

## Status

**Continuing.** Initial efforts look good.

## Finding #13

Recent downsizing and limitations on hiring have produced a workforce with aberrations in normal career development patterns and a potential future shortage of experienced leadership.

## Recommendation #13

Develop and implement a long-term workforce plan, focused on retention, recruitment, training, succession, and career development needs, with at least a five-year time horizon that will ensure the availability of competent and experienced leaders. Also provide a strengthened capability in organizational development.

## Response

Code F – Concur: NASA concurs with the recommendation. The recent experience with downsizing, coupled with Agency concerns about an aging workforce, demonstrate the importance of long-term human resources planning.

In 1998, under the auspices of the Chief Engineer's Office, the Agency conducted a core capability assessment that focused on the physical and staffing needs of the Enterprises and Centers of Excellence. This, and other similar activities, while very helpful, resulted in tactically-oriented decisions related to solving near-term human resource issues.

The Agency is now embarking on a follow-on strategic resource planning activity, based on Centers' future vision and mission, taking into account workforce and facilities needed. This activity, led by the Associate Deputy Administrator, involves the active participation of the Enterprises and Centers and support from the Office of the Chief Financial Officer, the Office of Human Resources and Education, and the Office of the Chief Engineer. The result will provide a plan for each Center that links staffing, funding resources, mission and activities, and core competencies and will enable them to focus on recruitment, retention, training, succession and career development tailored to their individual circumstances.

Once this activity has been completed, the Office of Human Resources and Education will continue to work with the Center Human Resources Directors to assess the impacts of demographic trends. Together the Human Resources community will develop plans that ensure that the Agency has the requisite staffing, training, career development, and recruiting and retention tools and programs necessary to support the Agency mission.

In addition, the Office of Human Resources and Education has been actively engaged, with input and support from the Enterprises and Centers, in a number of activities and initiatives to renew and revitalize the NASA workforce. These range from activities to recruit, retain, and continue development of a highly capable workforce today to endeavors to ensure a future source of highly qualified talent in the science, math, and technology disciplines needed to carry out the Agency mission over the long term.

With respect to recruitment, the Agency is committed to marketing NASA as an "employer of choice." In order to be competitive with other employers, NASA recognizes that it must have a continuing presence on college and university campuses. The more than 140 on-cam-

pus recruitment trips scheduled for this coming fall and spring 2002 are typical of this presence. In addition, the Agency will continue to utilize the Presidential Management Intern Program and student employment programs as sources for entry-level hires. NASA will also continue to promote the Internet as a recruitment tool and to work collaboratively with professional organizations (i.e., National Association of Colleges and Employers and National Academy of Public Administration) in an effort to remain competitive.

Our NASA Centers utilize various hiring authorities that enable them to offer starting salaries above the minimum rate of a grade. The use of recruitment bonuses by the Centers to attract the “best and the brightest” has also increased significantly in the recent past. The number has increased more than 300% from FY 1999 to FY 2000 (from 20 in FY 1999 to 69 in FY 2000 and 14 in just the first quarter of FY 2001) – a trend that we fully expect to continue because of an increasingly competitive job market and high cost of living surrounding some of our Centers.

In addition to these ongoing efforts, NASA will continue to be innovative in its recruitment efforts. We are implementing new automation tools, i.e., a position description management software package and two staffing software packages to improve the effectiveness and timeliness of the hiring process. We are enhancing the Agency’s human resources websites to make them more responsive to applicant information needs. Further, we are developing new qualification requirements for cooperative education students in order to more effectively recruit. Additional non-permanent employment options are being pursued where they are practical and the Agency is working with the Office of Management and Budget (OMB) and the Office of Personnel Management (OPM) to facilitate new employment options. The Agency has a new five-year plan for the employment of people with disabilities and will develop other outreach efforts designed to maintain a diverse workforce.

A new National Recruitment Team, based at Headquarters, is currently being established to develop new Agency-wide recruitment strategies and tools to meet NASA’s current and future hiring challenges in attracting and retaining a world-class, highly technical and diverse workforce. This team will facilitate and complement the Centers’ recruitment efforts; collaborate with the Institutional Program Offices and Functional Offices; enhance relationships with universities; eliminate duplication of efforts; and facilitate targeted diversity and disability recruiting.

The retention of a highly skilled workforce is equally vital. While the use of retention allowances has more than doubled from 5 in FY 1999 to 12 in FY 2000 (and 7 in the first quarter of FY 2001), this rate of usage has been impacted by downsizing and restructuring efforts in recent years and the continuing need to offer targeted buyouts to deal with our skills imbalances. NASA will continue to assess the skills of its workforce and restructure as necessary through buyout and early out retirement incentives to assure that NASA has the necessary skills for present and future mission success. In addition, we continue to emphasize quality of work-life initiatives such as alternative work schedules, family friendly leave programs, part-time employment and job sharing, telecommuting, dependent day car and employee assistance programs. Promoting safety in the workplace, providing effective awards, recognition and stimulating work will enhance job satisfaction and foster retention.

In the arena of developing competent and experienced leaders, in the last 18 months NASA conducted a leadership study and created a model to align development of our leaders to the NASA Strategic Plan and Strategic Management System. The study included benchmarking, working with universities, and the results of interviews of over 500 NASA/JPL employees

performing in leadership roles from team lead to executive senior leader. This model provides a roadmap of skills and competencies for effective NASA leadership and is being used to respond to the training and developmental needs of the workforce. As part of NASA's strategy to prepare our next generation of leaders, there are several long-term developmental processes in place at both the Center and Agency level. These include the Senior Executive Service Candidate Development Program, the Professional Development Program, partnerships with academia to provide fellowships in leadership and project management development, and Center-specific development programs. In addition, the curriculum for developing project management leaders is being reviewed to ensure that appropriate skills and competencies are developed.

In the area of organization development, one of the features which will be enabled by an increase in training resources is the ability to provide intact team support. By providing developmental intervention to teams, NASA will be able to contribute to improved performance of teams, as well as better prepare individual team members for future opportunities. NASA is also engaged in a strategy to develop employees in the theories, methods and tools of learning organizations. Pilots are showing that these skills enhance motivation, communication, and understanding of complex systems. Several Centers have also increased their organizational development resources and capacity and are offering facilitation services to their organizations.

The Agency is also looking at ways to help assure a future pipeline of talent from which the NASA and others can draw. FY 2001 marks the pilot year of the new NASA Undergraduate Student Research Program. This Agency-wide program was developed to extend and strengthen NASA's commitment to educational excellence and university research, and to highlight the critical need to increase the Nation's undergraduate and graduate science, engineering, mathematics, and technology skill base. The Undergraduate Student Research Program will also build a national program bridge from existing NASA K12 Education Program activities to NASA Higher Education Program options that encourages and facilitates student interest in future professional opportunities with NASA and its partner organizations. Such opportunities might include NASA career employment; temporary assignment; undergraduate and graduate co-op appointment; or contractor positions.

## Status

**Continuing.** Good progress.

## Finding #14

While NASA has made major changes to emphasize the need to utilize IV&V on safety critical projects, the technology is not well understood by program managers and other relevant NASA personnel.

## Recommendation #14

Develop an appropriate user-centered course and require software assurance awareness training for all levels of management to help them become more cognizant of the IV&V processes and the value IV&V brings to a final product.

## Response

Code AE - Concur: As the report points out, NASA has indeed made major changes to emphasize the need for IV&V on mission critical software. The software IV&V policy, criteria, and process for evaluation of projects is in place and being followed. The Office of the Chief Engineer has presented pertinent information to all Center Directors, emphasizing the importance of IV&V, and communicating the expectation that IV&V and the IV&V policy be incorporated in Center processes. The Goddard Space Flight Center has been making presentations about the policy, criteria, and process in greater detail to other levels of management including program and project managers whose projects meet the criteria for IV&V or independent assessment by the IV&V facility. In addition, the Office of Human Resources and Development is planning the update of existing training in Verification and Validation, and Test and Evaluation to include IV&V and the appropriate application of the same.

## Status

**Continuing.** NASA has made excellent progress in planning and developing training courses and materials to achieve a better understanding of the need for, and value of, IV&V and software assurance in NASA systems.

## Finding #15

NASA's reorganized IV&V activities place more emphasis on enforcing requirements than on researching and developing methods to perform IV&V for such emerging technologies as neural nets and expert systems.

## Recommendation #15

Ensure the continuation of a strong, focused software assurance and peer reviewed IV&V research program.

## Response

Code M - Concur: NASA recognizes the importance of peer reviewed research in software assurance tools and methodologies for more efficient and effective Verification and Validation of present software systems, as well as for the development of new tools and methodologies for emerging paradigms. The existing research program in software assurance sponsored by the Office of Safety and Mission Assurance is now placing greater emphasis on IV&V. In addition, NASA is establishing a High Assurance Consortium comprised of the country's leading institutions in computer science and Information Technologies to conduct fundamental research in software assurance. The consortium includes West Virginia University, who role will include the transition of technology into the IV&V center, and the development and implementation of IV&V training technology and methodologies.

## Status

**Continuing.** The Panel is heartened to see that NASA is committed to placing increased emphasis on software research and hopes it will continue. More detailed plans are needed for research activities focused on emerging software paradigms.

## Finding #16

NASA has initiated a well-founded, broadly encompassing computer security program to ensure that its computer systems are protected from hostile attacks, but development of security plans for all systems is lagging. Also, the function of Computer Security Officer has typically been added to the responsibilities of system administrators.

## Recommendation #16

16a Complete and maintain security plans for all appropriate computer systems and ensure that the computer security program is sustaining.

16b Ensure that computer systems administrators are properly trained in computer security.

## Response 16a.

Code AO - Concur: We concur with the ASAP recommendation. Progress since the ASAP review consistent with the recommendation is shown below:

### Current Status of Computer Security Plans and Sustainability of Computer Security Program

- Status of Computer Security Plans: As of the second quarter of FY 2001, computer security plans for 100 percent of SMA (Special Management Attention) Systems have been completed, including authorization to operate; 97 percent of SMA Systems have all protective measures completed as stipulated in their plans; three systems have completed interim measures that give adequate security. SMA Systems are NASA's most critical systems.
- Sustainability of Computer Security Program: In FY 1999, NASA spent \$28 million on IT security programs and measures. That amount has more than tripled in FY 2000 as NASA introduced an aggressive, Agency-wide program that stressed closer monitoring, improved reporting, expanded training, and better technology. The FY 2000 budget of \$91 million targeted the Space Flight and Earth Science Enterprises for particular emphasis, with those two business units receiving 80 percent of the ITS budget.

### Future Computer Security Plans for Computer Systems and Plans for Ensuring Sustainability of the Computer Security Program

- Future Computer Security Plans for Special Management Attention (SMA) Systems:
  - SMA Systems:
    - By September 30, 2001 – remaining 2.4 percent of systems have completed protective measures stipulated in their plans;
  - Mission (MSN) & Business & Restricted Technology (BRT) Systems:
    - By June 1, 2001 – 100 percent have IT security responsibility assigned;
    - By October 1, 2001 – 100 percent have signed IT Security Plans authorizing processing.

Sustainability of the Computer Security Program: The Agency will increase the ITS budget by over ten percent in FY 2001 to \$101 million, primarily to improve monitoring, protect data, and enhance technology at all Centers.

## Status

**Continuing.** Going well but needs additional attention in light of the events of September 11.

## Response 16b.

Code AO - Concur: We concur with the recommendation. Status of system administrator training is shown:

### Current Status of Computer Security Training for Systems Administrators

- As of the first quarter of FY 2001, 35.6% of system administrators have received basic awareness training and IT security training for UNIX or NT systems. This is below the target of 50%.

### Future Computer Security Training Plans for Systems Administrators

#### System Administrators

- By October 1, 2001— 90 percent of all system administrators completed during FY 2001 either the FY 2000 or the FY 2001 “ITS Overview” training on SOLAR or equivalent training.
- By October 1, 2001- 80 percent of administrators of UNIX systems completed “UNIX Security for System Administrators” training on SOLAR or equivalent training.\*
- By October 1, 2001 – 80 percent of administrators of NT systems completed “NT Security for System Administrators” on SOLAR or equivalent training.

We believe that the ITS program has made significant progress in the past two fiscal years as indicated in our response.

## Status

**Closed.** The plan looks good and most training has been accomplished.

## Finding #17

NASA has initiated plans to have its critical systems processes evaluated according to the Capability Maturity Model (CMM) of the Software Engineering Institute and to work toward increasing the CMM level of its critical systems processes.

## Recommendation #17

Implement the plan and ensure that all critical systems development programs comply.

## Response

Code AE - Concur: One of the major actions of the NASA initiative to improve the quality and reliability of software developed by or acquired by NASA, is to develop and implement a plan for all the Centers to achieve a level of capability commensurate with CMM level 3 for areas responsible for critical software development. The Office of the Chief Engineer has chartered the NASA Software Working Group, comprised of senior software experts from all the Centers to develop, facilitate, and oversee the implementation of such a plan. The plan is scheduled for completion in FY01. We will begin implementing appropriate elements in FY01 through pilots at first, to be followed by larger scale implementation consistent with the availability of funds for such effort.

Furthermore, JSC has taken the initiative to have its critical systems processes evaluated according to the Capability Maturity Model (CMM) of the Software Engineering Institute (SEI). ISS has a plan in place for implementation of the SEI 5-level CMM model on all of its software processes and is working closely with Boeing on this effort. The plan lays out a short-term goal of achieving a CMM level 3 and a long-term goal of level 5 on all of its critical software processes.

## Status

**Continuing.** This activity is well thought out. The Software Working Group has developed an excellent, comprehensive plan that is flexible enough to benefit all Center software development activities.

## Finding #18

The MDMs on the ISS are already at the 65 percent utilization design limit of their central processor unit (CPU) with four major software releases still to come. There is no identified method for accommodating the inevitable increasing demands on the CPU.

## Recommendation #18

Proceed expeditiously to upgrade the MDM computer system.

## Response

Code M - Concur: Honeywell has completed a concept design of an upgraded processor (from the Intel family) that can be used as card replacement for the CPU card in the enhanced MDM. The time from turn-on to delivery of the new cards was estimated at 24 to 30 months. The replaced enhanced CPU cards could then be used in any Standard MDM requiring additional processing or memory capability. It should be noted that Boeing was able to reduce the CPU requirements for the C&C software by 20% as part of the revision 2 development. While the pressure has been relieved in the short term, the processor upgrade will continue to be worked.

## Status

**Continuing.** The process to upgrade the MDMs is underway.

## Finding #19

Even though the most significant unknown in crew composite radiation exposure may be the contribution of neutrons, the Evolutionary Plan for the Crew Health Care System (CheCS) only lists a neutron monitor as a "Future Medical Requirement," and a project to fly a neutron detector is not planned until Increment 2.

## Recommendation #19

Accelerate the development of effective and reliable personal and area neutron dosimeters.

## Response

Code M - Concur: Crew and area dosimetry now include the use of four distinct thermo luminescence crystals of distinct sensitivity to neutron effects. This approach allows for the identification of the fraction of the crew radiation dose due to low-energy neutrons.

The tissue equivalent proportional counter (TEPC) was developed in the 1950's to measure radiation fields. NASA developed and has flown a flight version of the TEPC for 10 years. All STS missions and the ISS include an active TEPC that detects neutrons. And charged particles in the relevant energy range with good efficiency. However, the TEPC cannot distinguish neutrons from charged particles.

A project to fly the Bonner Ball Neutron Detector in collaboration with the National Space Development Agency of Japan is planned beginning on Increment 2. This instrument will provide a spectrum of the neutron energies incident on the ISS. The neutron spectrum analysis will allow determination of proper weighting of the TEPC data.

The development of active personnel monitor(s) using silicon detector technologies is being evaluated for flight use on Shuttle and ISS.

In addition, NASA uses state-of-the art radiation transport codes that include neutron reaction processes. These codes have become the standard engineering tool used for spacecraft design.

## Status

**Continuing.** Work has been initiated.

## Finding #20

The current EMU is adequate for the near-term needs of the ISS and the Space Shuttle, but its obsolescent technology, high cost, and other limitations make it unsuitable for future exploration and development of deep space.

## Recommendation #20

Initiate a high priority program to design and develop a next generation space suit.

## Response

Code M - Concur: The EVA project office has reviewed the FY2000 report from the Aerospace Safety Advisory Panel (ASAP) and concurs with recommendation to initiate a next generation space suit. The EVA office has been actively involved for several years in supporting and providing focus for the needed advances in suit related technologies to position the Agency for the next generation EVA system (space suit). The next generation space suit will address the issues in the finding, such as lowering the per unit and operational costs and allowing for utilization of the suits for the NASA's exploration mission scenarios. The next generation suit program has been delayed due to lack of sufficient funding.

## Status

**Continuing.** This work needs to get started.

# Appendix C

## Aerospace Safety Advisory Panel Activities January–December 2001

### January

January 10, 2001	Kennedy Space Center, STS-98 Flight Readiness Review
January 11, 2001	Kennedy Space Center, RSRM Process Review
January 16–17, 2001	Ames Research Center, IT Security, Design to Safety, Fairmont Transition, Carnegie-Mellon, SOFIA, Aviation Safety Officer's

### February

February 1, 2001	Kennedy Space Center, SSP Infrastructure Revitalization
February 7–8, 2001	NASA Headquarters, Annual Meeting
February 13, 2001	NASA Headquarters, ASAP Charter Discussions
February 20–21, 2001	Johnson Space Center, Stafford Task Force - Expedition 2 Status
February 26, 2001	NASA Headquarters, Aerospace Technology Tag-Up
February 27, 2001	Kennedy Space Center, STS-102 Flight Readiness Review
February 28, 2001	Space Station Program Launch Simulation

### March

March 13, 2001	NASA Headquarters, SFAC Meeting re: Shuttle Upgrades
March 13–15, 2001	Ames Research Center, AvSTAR Workshop
March 14, 2001	Boeing/Rocketdyne, Canoga Park, CA, SSME, Process Control, Linear Aerospoke, International Space Station EPS, RS-68
March 15, 2001	Boeing RSS, Huntington Beach, CA, General Status, Work Documentation, Integrity of Orbiter Fleet, Orbiter Metrics, Sustaining Engineering, Process Control, OV-102 OMM, LL Database, ISS Construction, Engin. Org.
March 20–21, 2001	Kennedy Space Center, Work Documentation, General KSC, SRB, Workforce (Super Tech.), SSPF, USA Reorg./CLCS Status
March 28, 2001	Johnson Space Center, Test Plan/Results from Parachute/Drogue System/Space Flight Test Plan, Alternate X-38
March 29, 2001	NASA Headquarters, ISS HQ Meeting. Annual Meeting Action Items

## April

April 4, 2001	Telecon w/KSC/Shannon Bartell re: ILP Issues
April 5, 2001	Kennedy Space Center, STS-100 Flight Readiness Review
April 10, 2001	Glenn Research Center, Aero Propulsion Research, General Aviation Propulsion, Icing Research
April 12, 2001	NASA Headquarters, Meeting w/Office of Space Flight
April 19, 2001	White Sands Test Facility, ISS Power, SSME RCS Valve Test
April 25–26, 2001	Johnson Space Center, General ISS and Shuttle, Plenary
April 27, 2001	Johnson Space Center, X-38 Software, IV&V, SAIL, MEIT, IT Security

## May

May 21, 2001	NASA Headquarters, Panel Reorganization
May 22, 2001	NASA Headquarters, Intercenter Aircraft Operations Panel Meeting
May 23, 2001	Rocketdyne, Canoga Park, CA, Integrated Logistics Panel Meeting
May 29, 2001	NASA Headquarters, ISS C&C MDM Telecon/Meeting
May 29-30, 2001	Johnson Space Center, ISS C&C MDM Independent Review

## June

June 1, 2001	NASA Headquarters, Panel Membership Telecon
June 5, 2001	Marshall Space Center, SRB, RSRM, ET
June 6, 2001	NASA Headquarters, Panel Membership Meeting
June 20, 2001	Kennedy Space Center, ET Maintenance Practices Review (USA)
June 26, 2001	NASA Headquarters, STS-104 Delta Joint Flight Readiness Review Tag-Up
June 26, 2001	Marshall Space Center, ET STS-105 Delta Preflight Review
June 27, 2001	NASA Headquarters, Panel Membership, Appointment Meeting w/Administrator
June 28, 2001	Kennedy Space Center, STS-104 Joint Flight Readiness Review

## July

July 3, 2001	NASA Headquarters, Meeting w/Office of Space Flight re: Structural Integrity
July 17, 2001	Johnson Space Center, Shuttle Structural Inspections

## August

August 1, 2001 Kennedy Space Center, STS-105 Joint Flight Readiness Review  
August 3, 2001 NASA Headquarters, Meeting w/Office of Space Flight re: Shuttle Structural Inspections Preliminary Report  
August 6, 2001 NASA Headquarters, Chief Engineer Briefing re: Software Development Plan  
August 21–22, 2001 NASA Headquarters, Plenary  
August 30, 2001 NASA Headquarters, Telecon w/ISS Avionics Office re: C&DH Architecture  
August 31, 2001 NASA Headquarters, Telecon w/NRC re: C&DH Architecture  
August 31, 2001 NASA Headquarters, Telecon w/Boeing FCC Integration Team Lead re: C&DH Architecture

## September

September 6, 2001 Washington, DC, Testimony to Senate  
September 6–7, 2001 San Antonio, TX, Shuttle PMR  
September 11, 2001 Dryden Flight Research Center, Flight Operations Review  
September 26–27, 2001 Kennedy Space Center, Shuttle Suppliers Conference

## October

October 1, 2001 NASA Headquarters, Briefing to Administrator re: ISS C&DH Architecture  
October 15–19, 2001 Ames Research Center, Intercenter Aircraft Operations Panel Meeting  
October 18–19, 2001 Johnson Space Center, Damage Control System, SSP Upgrades, Crew Debrief, MOD Status, Plenary  
October 30, 2001 Langley Research Center, Flight Operations, Wind Tunnel Review

## November

November 1–2, 2001 Thiokol, Wasatch, UT, General Status, SRB, EMT No. 02 Test  
November 7–9, 2001 Kennedy Space Center, CLCS, MEIT, ISS Hardware Status, Workforce, Work Paper, Plenary  
November 15, 2001 Kennedy Space Center, STS-108 Joint Flight Readiness Review

## December

December 5, 2001 NASA Headquarters, Kennedy Space Center Security Debrief w/Office of Space Flight  
December 5-6, 2001 NASA Headquarters, Editorial Committee Meeting





National Aeronautics and  
Space Administration

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