appear to have the Space Shuttle contracting process well in hand with safety paramount at every turn. Because of this and, possibly, because the restructuring is still in early stages, other than the aforementioned issue of KSC morale, safety problems have been few to non-existent. The cautious approach taken thus far is commendable. Nevertheless, the potential for safety problems remains. NASA leadership and top management should therefore continue active and detailed involvement in the safety aspects of planning for and oversight of NASA reorganization in general and Space Shuttle operations in particular.

Ref: Finding #33

NASA has decided to restructure and downsize its Space Shuttle operations. Many NASA personnel now working on Space Shuttle operations and sustaining engineering will be relieved of those duties. A contractor will take on an increased level of accountability and responsibility for day-to-day Space Shuttle operations. NASA will continue to have overall Space Shuttle responsibility and liability and will still be responsible for safety, flight manifest and the space flight operations budget as well as for recruiting, selecting and training crews.

As part of this plan, NASA personnel will no longer be involved in dealing with nonconformances of hardware, software and configuration requirements which are "within family." The concept is that if the task is simply to return the system to its prespecified state from a condition which has been successfully dealt with before, there is no reason for NASA to become involved. Theoretically, this is reasonable. A problem arises, however, in arriving at a suitable definition for determining if a condition is in or out-of-family and in the use of that definition on a daily basis.

The extremes of operating experience present little problem. For example, if a component or system fails which has never failed before or a serious mishap occurs, it is clearly out-of-family. Conversely, if a wear item continues to wear on every flight, that would represent an obvious in family occurrence. The problem is with many situations which fall between these extremes. Perhaps a problem which has been seen before is becoming more frequent or severe (e.g., the nozzle O-rings or the solid rocket booster pressure spikes) or one which has not been noticed for many flights suddenly starts to recur. For these types of situations, it may be extremely difficult to arrive at a definition for out-of-family which is sufficiently clear-cut. Moreover, the eventual definition of out-of-family will likely carry with it so much "overhead" that a contractor may have a strong incentive ***not*** to classify something as out-of-family whenever possible especially if the contractor bears little or no liability for an incorrect decision.

Given the importance of the definition of "out-of-family," it would seem essential for NASA personnel with direct Space Shuttle operations experience to be involved in the process of developing a definition. The derivation of the criteria for out-of-family by itself, however, will not be enough to guarantee appropriate checks and balances involving consultation with NASA. A process will have to be devised which permits NASA personnel to monitor decision-making on the status of non-conformance situations. Through this mechanism, NASA will be able to ensure that it is a part of the decision making in all situations which could potentially involve loss of crew, vehicle or significant financial resources or a major compromise to the Space Shuttle launch schedule.

Finally, the proposed future role of NASA causes a bit of a dilemma. NASA has said that it will approve all dispositions for out-of-family non-conformance. With the proposed reductions of NASA personnel in operational roles, a question arises concerning what basis those in the NASA oversight role will have for making and enforcing these judgments. Initially, people can be appointed who have been involved in a "hands on" manner with the Space Shuttle. Eventually, however, NASA will run out of people with direct operational experience. At that point, the effectiveness of the NASA inputs may be compromised and safety could suffer.

Ref: Finding #34

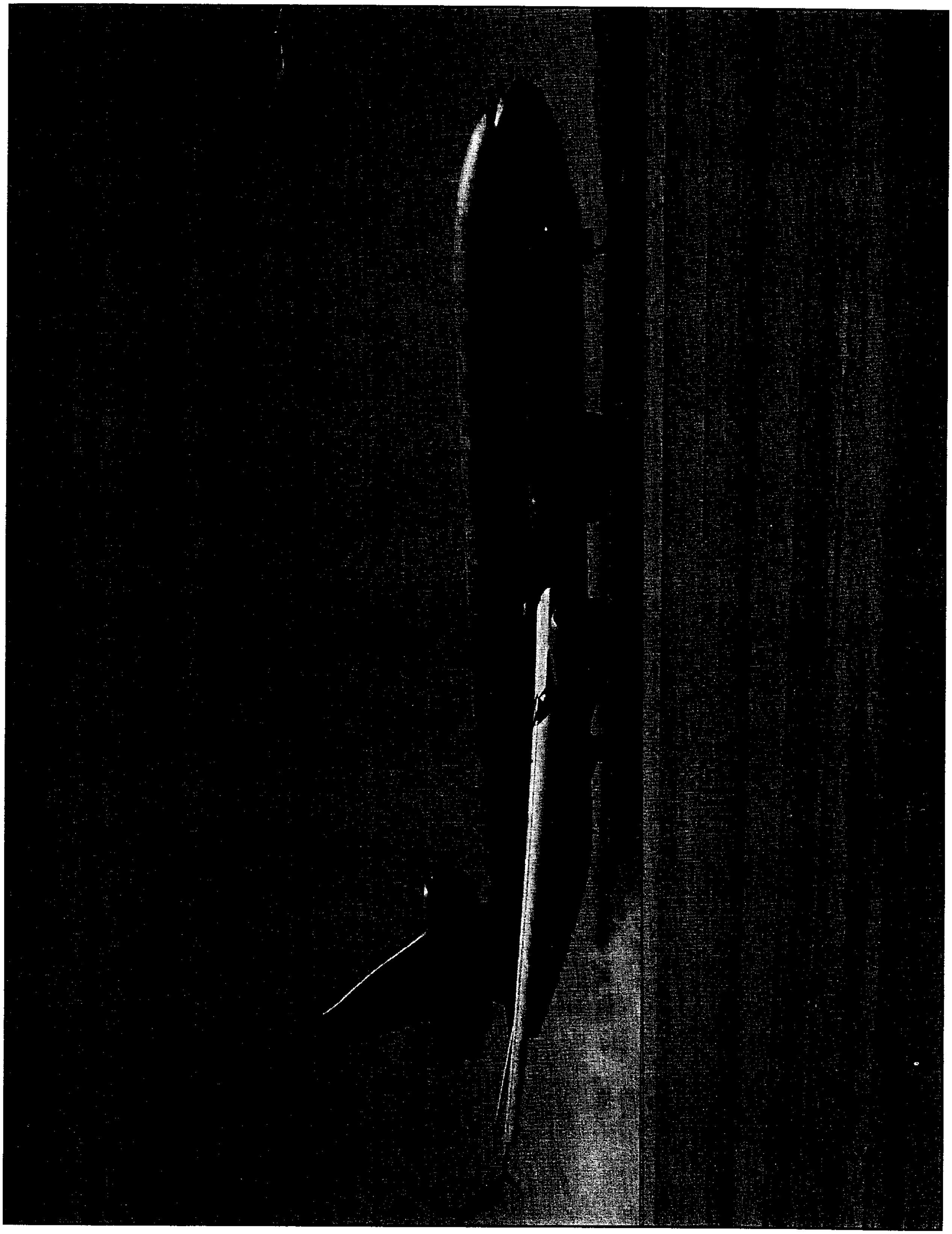
New propulsion control modes utilizing neural nets are under development at Dryden and Ames. These allow aircraft to be reliably landed under fault conditions that previously would usually result in crashes. Neural nets are now being introduced into the Propulsion Controlled Aircraft (PCA) system. The use of neural nets in flight control systems raises questions of how this controller software can be verified and validated for flight operations. At present, they go through the standard Dryden safety processes. The first neural net experiments should not represent a Verification and Validation issue because the neural net is used on one of three redundant channels and only for capturing data.

There is ongoing work to break the neural net operation into regions each of which might be more simply validated. Nevertheless, the opinion has been expressed that there is a technology/certification mismatch at present. There is a feeling that new criteria are needed for certification for advanced control software. The Ames Research Center in its capacity as designated center of excellence for information systems technology should undertake the research and technology necessary to provide NASA with appropriate V&V techniques for neural net control software.

Ref: Finding #35

There is at least one NASA Center which has only one NASA software person in its Safety and Mission Assurance (S&MA) office to handle all of the software assurance issues. Even when a few contractor personnel are added, this is an inadequate staffing level to accomplish much meaningful assurance work on software. Moreover, the contractor personnel are not allowed to work on a number of important software evaluations because of possible proprietary conflicts. Projects seem to have developed the habit of budgeting for hardware safety analyses with little or nothing allocated for software safety. It does not seem that software safety is taken seriously! By increasing importance of software in operating systems, there is an obvious need for the S&MA organizations to penetrate more broadly throughout the Centers and provide a level of assurance commensurate with the growing role of software. Given the existence of at least one example of an under staffed software assurance function, the Headquarters Office of Safety and Mission Assurance should examine the depth of the software assurance process at each of the Centers and promulgate NASA-wide standards for adequate coverage.

IV. APPENDICES



APPENDIX A

NASA AEROSPACE SAFETY ADVISORY PANEL MEMBERSHIP

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Consultant, Former Senior Vice President, Operations Services
Eastern Airlines, Inc.

<u>DEPUTY CHAIRMAN</u>

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MR. MELVIN STONE
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Former Director of Structures
McDonnell Douglas Corporation

<u>EX-OFFICIO MEMBER</u>

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Associate Administrator for Safety and Mission Assurance
NASA Headquarters

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MR. FRANK L. MANNING
Executive Director
NASA Headquarters

MS. PATRICIA M. HARMAN
Staff Assistant
NASA Headquarters

APPENDIX B
NASA RESPONSE TO MARCH 1995 ANNUAL REPORT

SUMMARY

NASA responded on July 14, 1995, to the "Findings and Recommendations" from the March 1995 Annual Report. 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 and recommendation 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 the next year. Items considered answered adequately are deemed closed.

Based on the Panel's review of the NASA response and the information gathered during the 1995 period, the Panel considers that the following is the status of the recommendations made in the 1995 report.

	RECOMMENDATION	
NUMBER	SUBJECT	STATUS
1	International Space Station (ISS) Independent Safety Assessment Function	CONTINUING
2	ISS Assured Crew Return Capability	OPEN
3	ISS Caution and Warning	OPEN
4	ISS Fire Suppression Effectiveness	OPEN
5	ISS Hazardous Materials and Procedures	CLOSED
6	ISS Orbital Debris Protection	OPEN
7	Russian Androgynous Peripheral Docking System (APDS) Hook Capture Indicator	CLOSED
8	APDS Backup Systems - Pyro Bolts	OPEN
9	Additional Space Shuttle Payload Capability	CLOSED
10	New Gas Generator Valve Module	CLOSED
11	Advanced Orbiter Displays/System Working Group	OPEN
12	Tactical Air Control & Navigation/Microwave Scanning Beam Landing System Obsolescence	CONTINUING
13	Data Processing Requirements Growth	OPEN
14	Improve Autoland Equipment and Crew Flight Rules and Training	CLOSED
15	Space Shuttle Main Engines (SSME) Inspection and Assembly Processes	CONTINUING
16	SSME Block II Modifications	CLOSED
17	SSME Health Monitoring	CONTINUING
18	SSME Block II Safety Improvement	OPEN
19	Super Lightweight Tank Ultimate Loads Test	CLOSED
20	Solid Rocket Booster Structural Tests	CLOSED
21	Critical Components Cannibalization	CLOSED
22	Integrated Logistics Panel	CLOSED
23	KSC Logistics Consolidation Plan	CLOSED
24	TU-144 Design and Safety Assessment	CLOSED
25	Wind Shear Research	OPEN
26	Tire Research Program	OPEN
27	Propulsion Controlled Aircraft System	CLOSED
28	Unmanned Aerial Vehicle Range Safety Policy	CLOSED
29	Simplified Aid for EVA Rescue	OPEN
30	Priority of Software Issues	CONTINUING
31	Independent Safety Oversight of Human Experiments	CLOSED
32	Aviation Safety Reporting System	CLOSED
33	Aircraft Operations Specialists Advisory Group	CLOSED
34	Total Quality Management	CLOSED

National Aeronautics and
Space Administration

Office of the Administrator
Washington, DC 20546-0001

JUL 14 1995

Mr. Paul M. Johnstone
Chairman, Aerospace Safety
Advisory Panel
24181 Old House Cove Road
St. Michaels, MD 21663

Dear Mr. Johnstone:

In accordance with Mr. Norman R. Parmet's introductory letter to the March 1995 Aerospace Safety Advisory Panel (ASAP) Annual Report, enclosed is NASA's detailed response to Section II, "Findings and Recommendations."

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

We thank you and your Panel members for your valuable contributions. ASAP recommendations receive the full attention of NASA senior management. We look forward to working with you.

Sincerely,

Daniel S. Goldin
Administrator

Enclosure

1995 AEROSPACE SAFETY ADVISORY PANEL REPORT

FINDINGS, RECOMMENDATIONS, AND RESPONSES

A. SPACE STATION PROGRAM

Finding #1:
The original organization of the International Space Station (ISS) Program included an independent safety assessment function reporting directly to the Program Manager. Subsequently, this was changed so that independent assessment reported directly to the Associate Administrator for Safety and Mission Assurance.

Recommendation #1:
Maintain the true independence of the safety assessment function by ensuring that it reports outside the Space Station Program.

NASA Response to Recommendation #1:
NASA agrees. The International Space Station Independent Assessment Team (IAT) reports directly to the Office of Safety and Mission Assurance (S&MA) at NASA Headquarters. At the same time, the S&MA team within the Space Station program provides early and continuous S&MA input to design and operations, allowing for efficient incorporation and implementation of the requirements. This is in addition to maintaining a reporting path to the IAT.

Finding #2:
The ISS Program has committed to providing an assured crew return capability. This will initially be accomplished by using a combination of docked Space Shuttles and Soyuz capsules. Once the ISS is permanently and fully staffed, a newly designed Assured Crew Return Vehicle (ACRV) will be deployed.

Recommendation #2:
The use of the Space Shuttle and Soyuz as an interim measure [for assured crew return] is an expedient. The planned new ACRV is definitely needed to support safety in the long term. The design of this permanent ACRV, regardless of where and when it is built, should be consistent with the design reference missions and systems requirements previously defined by the ACRV Office of the Space Station Freedom.

NASA Response to Recommendation #2:
NASA agrees. The ACRV documentation presently in place in the Space Station program (SSP 41000A and 50011-01 Rev A) is consistent with the design reference missions and systems requirements previously defined by the ACRV Office of the Space Station Freedom.

Finding #3:
The architecture of the ISS contains a Caution and Warning (C&W) system to detect and warn of malfunctions and emergencies, including toxic spills, depressurization and fire. The system makes use of laptop computers for localization of faults.

Recommendation #3:
Careful consideration should be given to the appropriateness of using laptop computers for a task as time critical as localizing life-threatening emergencies. The entire fault detection and localization process should use dedicated equipment to minimize response time.

NASA Response to Recommendation #3:
To address this issue, NASA has formed a temporary team, composed of personnel from Safety and Mission Assurance, Command and Data Handling, and other teams. Program resolution of these issues is expected by August 1995.

Finding #4:
The absence of experimental data for fire suppression effectiveness of the carbon dioxide extinguishers selected for use on the ISS under weightless conditions is a source of concern.

Recommendation #4:
Appropriate ground-based and in-flight research to confirm the suitability of the use of pressurized carbon dioxide fire extinguishers under weightlessness should be conducted.

NASA Response to Recommendation #4:
Ground testing performed during the Space Station Freedom program conservatively demonstrated the ability of the carbon dioxide fire extinguishers to produce adequate concentrations of fire suppressant in closed volumes, such as racks. Additional ground testing is being pursued to address areas, such as endcones and standoffs, not included in the Freedom configurations tested. Upon successful demonstration that these new configurations do not exceed the capabilities of the extinguishers to adequately perform, NASA will consider them to be suitable for use on the Space Station.

Finding #5:
The present procedures for monitoring or controlling hazardous materials and procedures used in ISS experiments are dependent on the experiment supplier complying with Station requirements and specifications.

Recommendation #5:
For hazardous materials and procedures used in Space Station experiments, NASA should establish a positive system of compliance assurance modeled after the one used by the Space Shuttle Program. This system should consider the entire service life of the experiment and its deactivation when completed.

NASA Response to Recommendation #5:
NASA agrees with and is complying with this recommendation. The Space Station program is using the same Payload Safety Review Panel (PSRP) that the Space Shuttle program is using, augmented with representatives from the Space Station program and the international partners. The PSRP process document has been levied on the Space Station program, as has the payload safety requirements document with a Station-specific addendum to cover the differing environments.

Finding #6:
Good progress has been made in defining the threat from orbital debris and in demonstrating efficient shielding configurations. A technical basis for a debris protection specification for ISS is emerging.

Recommendation #6:
Continue [orbital debris protection] design with emphasis on: structural integrity of habitable modules and pressure vessels; identification of the damage potential from direct impact and other depressurization events; and definition and development of operational procedures and policies.

NASA Response to Recommendation #6:
NASA shares the ASAP's areas of concern related to orbital debris. The Space Station program continues to place emphasis on the integrity of habitable modules and pressure vessels. As previously reported to the ASAP, we have implemented state-of-the-art enhanced shielding on the U.S. Laboratory and Habitation modules. Similar approaches are being taken by the international partners to meet Space Station requirements. We are also continuing efforts to identify damage potential from debris with ongoing penetration effects analysis and test activities at the Marshall Space Flight Center. Operational procedures and policies for risk mitigation are under development. Techniques for executing collision avoidance maneuvers are maturing and other activities, including penetration detection and repair, are ongoing.

B. SHUTTLE/MIR (PHASE ONE) PROGRAM

Finding #7:
The Russian Androgynous Peripheral Docking System (APDS) for docking the Space Shuttle with the Mir uses 12 active hooks on the Space Shuttle side which mate with an equal number of passive hooks on the Mir. The design currently provides no positive means of determining whether any or all of the hooks are secured. NASA has decided it is an acceptable risk to fly the first docking mission, STS-71, without an indicator.

Recommendation #7:
NASA should develop an indicator system.

NASA Response to Recommendation #7:
The second APDS unit, which is being procured from RSC-Energia for the second and subsequent Mir missions, also does not have individual structural hook position indicators. The addition of indicators was discussed with RSC-Energia, however, the APDS manufacturing and delivery schedule precluded installation. Johnson Space Center (JSC) and Rockwell engineers have shown, through test and analysis, that there is no threat to crew and vehicle safety for the remote failure case of two adjacent hooks failing to close properly. Combinations of failures that would result in crew injury or vehicle damage are considered to be of remote probability, the risk therefore being acceptable for the Phase I program. The Shuttle program has reviewed the test and analysis results and approved the APDS baseline without position indicators for the Mir missions.

The design specification for APDS units which will be procured from RSC-Energia for international Space Station mission applications currently requires position indication capability for all structural hooks on the orbiter (active) side of the interface, and position indication for gangs of three structural hooks on the station (passive) side. In addition, the APDS which will be installed on the Pressurized Mating Adapter-1, and controlled from the orbiter on Space Station Mission-2A, will have positive indications on all structural hooks.

Finding #8:
If the primary system fails, the first backup separation system for the APDS is a set of pyro bolts which disengage the 12 active hooks. Having to rely on the pyros as presently supplied by the Russian Space Agency poses risk because of lack of knowledge relating to the pyros' pedigree and certification. A second contingency demate procedure is available involving the Extravehicular Activity (EVA) removal of 96 bolts at a different interface. Implementing either backup method to separate Shuttle from Mir may leave the Mir port unusable for future dockings.

Recommendation #8:
NASA should emphasize increasing the reliability of the primary mating/demating mechanisms in order to reduce the likelihood of having to use either of the backups. NASA should also obtain an acceptable certification of the supplied pyro bolts. Failing that, NASA should procure fully certified substitute bolts.

NASA Response to Recommendation #8:
The APDS mechanism hardware has been demonstrated by test to fully meet its design environments. Additional detail regarding critical mechanical components was jointly developed by RSC-Energia, JSC, and Rockwell engineering, and analysis of those components has been completed. The analysis supports test results which demonstrate design margin for the life of the Mir program. Additionally, the results for this analysis will be used as a guideline in developing maintenance requirements for future Mir and Station missions. The pyrotechnics, installed in the APDS, have completed a confidence test that was developed by Rockwell and NASA engineering in conjunction with RSC-Energia and with the concurrence of NASA S&MA. NASA is pursuing design improvements of the RSC-Energia bolts for Station missions and is also working on the development of an American-built pyrotechnic bolt.
RSC-Energia has not been receptive to the idea of installing American bolts in the APDS; however, assembly schedules do not require a decision until late 1995, and discussions with RSC-Energia are continuing.

C. SPACE SHUTTLE PROGRAM

ORBITOR

Finding #9:
Significant additional payload mass capability is required to meet the demands of the assembly and supply plans. Much of the needed increase in capacity will be achieved through weight reduction programs on a number of Space Shuttle elements and subsystems. The large number

of simultaneous changes creates potential tracking and communication problems among system managers.

Recommendation #9:
Emphasis should be placed on the adequate integration of all of the changes into the total system.

NASA Response to Recommendation #9:
Integration of major changes into the existing Space Shuttle vehicle is receiving emphasis by the Space Shuttle program. The Space Shuttle program has had a system in place for many years to integrate all of the changes into the total system. This system has proven effective.

The system consists of technical panels, integrated product teams, and control boards. A technical panel exists for each major functional area (e.g., Loads and Dynamics, Thermal). These technical panels integrate and review the technical aspects of the analysis and testing. The functional areas are integrated by the integrated product teams (e.g., Propulsion System Integration Group) and at joint panel meetings.

The control boards, at the project and program level, provide a final technical review and integration, and management direction for cost and schedule control.

The NASA Element Project Offices and prime contractors are represented on the technical panels, integrated product teams, and control boards, allowing cross communication and input at all levels of the process.

There is a System Integration Plan for each of the major performance enhancements that defines the responsibilities of the affected elements, identifies deliverable products and hardware, and defines the system schedule for that enhancement to support the first element launch.

Finding #10:
The New Gas Generator Valve Module (NGGVM), when certified and retrofitted to the fleet, should mitigate many of the problems with the current Improved Gas Generator Valve Module in the Improved Auxiliary Power Unit (IAPU). The NGGVM development program is proceeding well.

Recommendation #10:
NASA should attempt to introduce the NGGVM into the fleet as soon as possible as a safety and logistics improvement.

NASA Response to Recommendation #10:
NASA intends to introduce the NGGVM into the fleet on an opportunity basis. The ground rule for this plan is to maintain a minimum Kennedy Space Center (KSC) stock level of five spare IAPU's to support any unplanned line replaceable unit removals. Any other IAPU's not required to support this stock level will be shipped to Sundstrand to undergo the NGGVM modification. By leaving this number of spare IAPU's on the shelf at KSC and modifying any units available

beyond that, the NGGVM implementation into the fleet can be completed in late 1998 or early 1999. Upgrade and modification of three Auxiliary Power Units currently not used for flight as an expedient to the NGGVM fleet retrofit is not cost effective.

Finding #11:
The decision has been made to install the entire Multi-Function Electronic Display System (MEDS) in each Orbiter during a single Orbiter Maintenance and Down Period (OMDP). An Advanced Orbiter Displays/System Working Group has been formed to plan for the next generation of MEDS formats and display enhancements.

Recommendation #11:
NASA should support the Advanced Orbiter Displays/System Working Group and set a timetable for the introduction of enhanced display
formats which will improve both safety and operability. It should also maintain its commitment to completing the MEDS installations during a single OMDP.

NASA Response to Recommendation #11:
NASA established the Advanced Orbiter Displays/System Working Group to define next-generation cockpit displays that will take advantage of MEDS data processing capabilities to improve safety and operability. The Government/industry working group is currently defining requirements for enhanced displays as well as a timetable for both evaluation of candidate displays in MEDS testbeds and introduction of new displays into orbiters.

NASA identified several advantages to installing MEDS hardware in orbiters during a single OMDP. Current OMDP planning as well as the schedule for first flight of MEDS on each orbiter reflects the single OMDP installation plan.

Finding #12:
The Tactical Air Control and Navigation (TACAN) and Microwave Scanning Beam Landing System (MSBLS) on-board receivers are obsolescent and increasingly difficult to maintain. The MSBLS receivers also have known design problems which can lead to erroneous guidance information if the orbiter is operating with only two of the three receiver complement. A Global Positioning System (GPS) test is underway on one of the orbiters using the backup flight software and computer. The use of GPS could replace both the TACAN and MSBLS systems as well as assisting ascent and on-orbit operations.

Recommendation #12:
Given the potential of GPS to improve safety and reliability, reduce weight and avoid obsolescence and the many existing and potential problems with the use of TACAN and MSBLS, a full GPS implementation on the orbiter should be accomplished as soon as possible.

NASA Response to Recommendation #12:
The Space Shuttle program is currently reviewing a plan to fully implement the GPS capabilities. The GPS hardware/software implementation plan calls for completing the installation of a redundant GPS hardware capability as early as the year 2000. The software implementation will be completed with delivery of the OI-27 operational increment by December 1997 with a first

flight effectivity in the summer of 1998. The redundant GPS hardware installation will be accomplished during the OMDP for each orbiter.

Finding #13:
Growth in the requirements for on-board data processing will continue as the Space Shuttle is used in support of Shuttle/Mir, ISS and other future missions. The length of time over which the General Purpose Computer and its software will be able to meet these growing needs effectively is likely inadequate.

Recommendation #13:
NASA should expedite a long-range strategic hardware and software planning effort to identify ways to supply future computational needs of the Space Shuttle throughout its lifetime. Postponing this activity invites a critical situation in the future.

NASA Response to Recommendation #13:
We concur that continued reliance on the Space Shuttle beyond 2005 will demand some major revisions to the core General Purpose Computer (GPC) hardware and software, if for no other reason than the inability to maintain hardware based on early 1980 technology. Such a revision, given the tightly coupled interdependencies of the present core architecture, would logically be accomplished as a major "block" update rather than gradually evolving to a new architecture. The block update approach can also serve to reduce future operations costs by stabilizing avionics hardware and software during the Station assembly era. In accord with that concept, the Space Shuttle program is considering an approach that would freeze the GPC software at roughly the turn of the century, following the incorporation of Station-driven enhancements. That freeze would allow for diversion of engineering resources, heretofore devoted to routinely evolving enhancements, to pursue a true significant block update sufficient to sustain the Space Shuttle past 2020.

As the foundation for such a possible architecture, the JSC Engineering Directorate has developed a Reduced Instruction Set Computer (RISC) for high-fidelity emulation of the present GPC. That emulation is capable of real-time bit-level execution of actual object code produced by the HAL/S compiler. It will soon be made available to allow flight software developers a target machine for early development testing. At the present time, such early testing is a premium because of the limited availability of real GPC's. The extension of the emulator concept, as a candidate to replace the actual flight GPC's, is the next logical step. It would preserve critical flight code, thereby minimizing the reverification costs, while still providing a modern platform for growth.

In summary, NASA does have the essential formative elements for a long-range strategic hardware and software upgrade effort in work. Existing limited resources and ongoing program activities obviously preclude any definitive strategic planning until completion of the current programwide restructuring activities. Once those activities are complete, a more definitive plan and schedule, predicated on critical examination of limited available resources, can be developed.

Finding #14:
The STS-64 mission involved a higher than usual level of windshield hazing which could have led to a situation in which the astronauts' view of the landing runway was obscured. MSBLS and TACAN are obsolescent. There is also the possibility that false indications by MSBLS under certain scenarios could result in an unacceptable risk of a landing mishap. Thus there is a clear need for early upgrade of orbiter and support facility autoland equipment and crew flight rules and training improvement.

Recommendation #14:
NASA should improve the autoland equipment on the Orbiter; for example, replacing MSBLS and TACAN with GPS. In the interim, NASA should ensure that operations and failure modes of MSBLS are fully examined and understood. NASA should also reexamine the training of crews for executing automatic landings, including autoland system familiarization. Astronaut commanders and pilots should discuss circumstances which might warrant autoland use prior to each mission and be prepared for all reasonable contingencies in its operation.

NASA Response to Recommendation #14:
Incorporation of GPS is being pursued as aggressively as funding and technical constraints will allow. The program has approved plans and funding to provide a single-string GPS capability that can be flown in the summer of 1997 as a first step toward TACAN/MSBLS replacement. Plans for a full three-string operational system have been approved for OI-27, and detailed costs and schedules are being assessed by the program. The failure modes of the MSBLS have been analyzed and are documented in the program's Critical Item List.

The finding made by the ASAP regarding the STS-64 mission, involving a higher than usual level of windshield hazing that could have led to a situation in which the astronaut's view of the landing runway was obscured, is incorrect. The STS-64 orbiter Quick Look Reports states: "Orbiter Windows 3 and 4 exhibited light hazing and streaks were seen on 4." Additionally, the Commander (Richard N. Richards, 4th flight) reports that the window hazing was not unusual at all, typical of what is usually seen, and an excellent view of the runway was obtained at all times during the approach, landing, and rollout phases of the flight. The STS-64 vehicle touchdown parameters were excellent, confirming that the Commander had an excellent view of all visual aids throughout the approach and landing. (These touchdown parameters include touchdown airspeed of 198 knots versus 195 planned, touchdown distance of 2386 feet versus predicted 2505, sink rate at touchdown of 1.0 feet per second, and a threshold crossing height of 20 feet. All parameters are excellent.)

Extensive analysis of the orbiter autoland system has been performed by various organizations in NASA, including exhaustive reviews by NASA Safety and Mission Assurance personnel. Those results have been briefed to all levels of NASA management. The Space Shuttle program has not identified/defined any hardware or software change that is necessary to improve the autoland capability. The operational use of the autoland capability remains at the discretion of the mission commander. To educate pilots and commanders on the use of this emergency system, Mission Operations Directorate (MOD) provides a briefing that covers the capabilities and limitations of the autoland system, as well as the contingency cases for which it is a viable alternative (i.e., both pilots incapacitated, or a highly inaccurate weather forecast for landing). In addition, each crew has a session in the Shuttle Mission Simulator, as well as the Shuttle Training Aircraft where the autoland system is demonstrated and discussed.

SPACE SHUTTLE MAIN ENGINE (SSME)

Finding #15:
It has become necessary to execute a partial disassembly of both the engines and turbopumps after each flight because of the accumulation of special inspection requirements and service life limits on components of the current (Phase II) SSMEs. These inspections are performed with rigor and appropriate attention to detail.

Recommendation #15:
In order to control risk, NASA must maintain the present level of strict discipline and attention to detail in carrying out inspection and assembly processes to ensure the reliability and safety of the SSMEs even after the Block I and Block II upgrades are introduced.

NASA Response to Recommendation #15:
NASA agrees with this recommendation and will continue to perform the detailed inspections of the Phase II Space Shuttle Main Engines (SSME) that are currently defined. The postflight inspections of both the Block I and Block II SSME's will be significantly less in frequency than those for today's Phase II SSME due to the major design changes, especially in the turbopumps. However, the program plans to use the same level of strict discipline and attention to detail in carrying out the new inspection program as it has in the past.

Finding #16:
The re-start of the Advanced Turbopump Program (ATP) High Pressure Fuel Turbopump (HPFTP) and the start of the Large Throat Main Combustion Chamber (LTMCC) developments were authorized in the spring of 1994. Combined with the ongoing component developments of the Block I engine, this will produce a Block II engine which will contain all of the major component improvements that have been recommended over the past decade to enhance the safety and reliability of the SSME. Both the Block I and Block II programs have made excellent progress during the current year and are meeting their technical objectives.

Recommendation #16:
Continue the development of the Block II modifications for introduction at the earliest possible time.

NASA Response to Recommendation #16:
NASA agrees with this recommendation. The first flight of the Block I SSME was on STS-70, which was launched on July 13, 1995. The Block II SSME will be available for flight in September 1997.

Finding #17:
In order to provide an engine health monitoring system that can significantly enhance the safety of the SSME, improvements must be made in the reliability of the engine sensors and the computational capacity of the controller. It is also essential to eliminate the difficulties with the

cables and connectors of the Flight Accelerometer Safety Cut-Off System (FASCOS) so that vibration data can be included in the parameters used in the algorithms that determine engine health.

Recommendation #17:
Expand and emphasize the program to improve engine health monitoring. Continue the program of sensor improvements. Vigorously address and solve the cable and connector problems that exist in FASCOS. Continue the development of health monitoring algorithms which reduce false alarms and increase the detectability of true failures.

NASA Response to Recommendation #17:
The Space Shuttle program is implementing Discharge Temperature Thermocouples as a replacement for the current temperature sensors on the SSME's. No other health monitoring improvements are funded at this time because the design was not mature enough to make this a cost-effective project.

Finding #18:
The Block II SSME can improve safety if an abort is required because it can be operated more confidently at a higher thrust level. This will permit greater flexibility in the selection among abort modes.

Recommendation #18:
NASA should reexamine the relative risks of the various abort types given the projected operating characteristics of the Block II SSMEs. Particular emphasis should be placed on the possibility of eliminating or significantly reducing exposure to a Return to Launch Site abort.

NASA Response to Recommendation #18:
Operating the Block II SSME's at a higher power level requires completion of two certification activities—the Block II SSME hardware certification and the integrated vehicle intact abort certification (loads, thermal, guidance, navigation and control). Because the internal environments and stresses are significantly reduced for Block II SSME's, the Space Shuttle program approved certification testing to include 109-percent power level for intact abort operations. This allows for the future consideration of increasing the power level for intact aborts to 109 percent pending the results of certification testing. If the increase in power level for intact aborts proves feasible, it would reduce, but not eliminate, exposure to the Return-to-Launch Site abort mode. Performance enhancements vehicle ascent certification environments are currently being developed using 106-percent power level for intact abort operations to improve abort performance and to minimize the risk of design impacts to the Space Shuttle vehicle. A delta certification plan to incorporate 109-percent power level for intact abort operations is currently being developed. Implementation of the plan is contingent on a successful Block II SSME test program, the results of vehicle thermal and structural loads trade studies, and the delta certification cost and schedule. Further, even if certification is successful, the decision to utilize 109-percent power level for intact aborts will depend on actual flight experience with the Block II SSME's.

EXTERNAL TANK

Finding #19:
The liquid oxygen tank aft dome gore panel thickness of the Super Lightweight Tank (SLWT) has been reduced significantly on the basis of analyses. To stiffen the dome, a rib was added. The current plan to verify the strength of the aft dome involves a proof test only to limit load. Buckling phenomena cannot be extrapolated with confidence between limit and ultimate loads.

Recommendation #19:
The SLWT aft dome should either be tested to ultimate loads or its strength should be increased to account for the uncertainties in extrapolation.

NASA Response to Recommendation #19:
NASA agrees with this recommendation. At the joint NASA and Martin Marietta Aluminum Lithium Test Article (ALTA) Design Review on August 19, 1994, an aft LO2 dome test was added to the ALTA test program. Adding this stability test will permit the aft dome to be verified to the ultimate load condition. The as-planned test satisfies the buckling concerns of Finding #19.

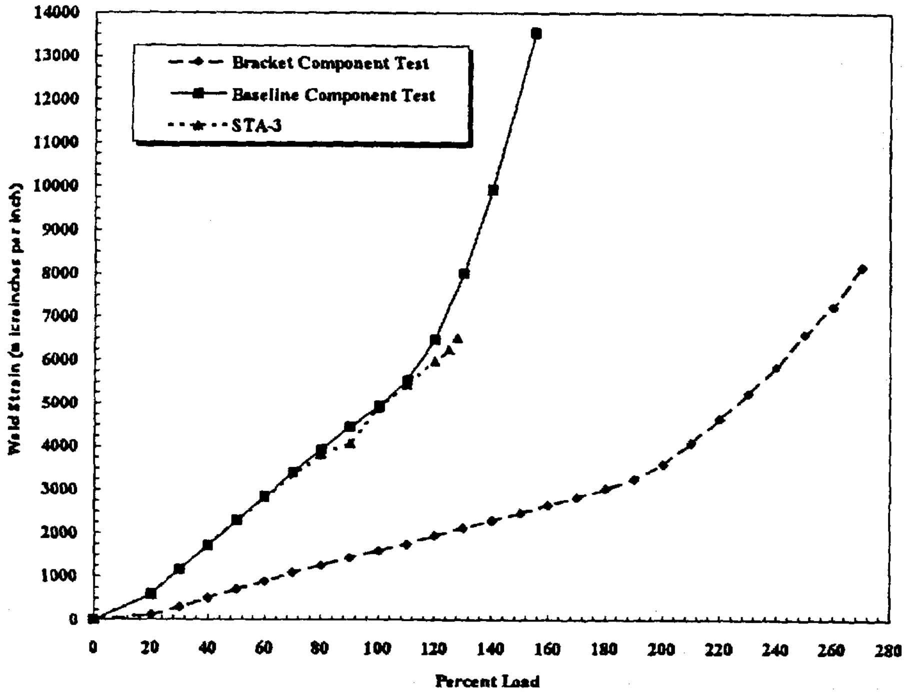
SOLID ROCKET BOOSTER (SRB)

Finding #20:
The structural tests of a segment of an SRB aft skirt in the baseline configuration did not duplicate the strains and stresses previously measured in the tests of the full-scale aft skirt Structural Test Article (STA-3). This suggests that segment testing of the proposed bracket modification to improve the aft skirt's factor of safety may not be valid.

Recommendation #20:
NASA should reassess the use of the segment test method and reconsider the use of a full scale test article for qualifying the proposed bracket reinforcement.

NASA Response to Recommendation #20:
At the time of the NASA response to the March 1994 ASAP Annual Report, two initial test condition baselining test articles (TA) had been tested to 100- and 70-percent load levels. The TA-1 and TA-3 test loads were analytically derived and validated using empirical data from these tests and STA-3. The TA-3 baseline testing showed excellent correlation with strain response curves measured during the STA-3 test. In addition, a second test article was tested to failure. Strain data obtained from these two specimens was compared to the STA-3 strain data (up to 128-percent loads which was the maximum load level achieved prior to failure initiation during the STA-3 test program). Data from second baseline test, the bracket test, and STA-3 are depicted in the figure below. The strain measurements for the critical weld region for the full-load applications (0 to 128-percent loads) exhibit an average correlation within 8.6 percent and, at 128-percent load levels, the average correlation is within 9.6 percent.

The first of the two test articles that were tested to failure failed at 167-percent load level; the second at 155-percent load level. The corresponding strains at the indicator gage at failure were ~17,000 and ~13,500 microstrain; by comparison, the STA-3 measurements indicated 6,704 microstrain at 128-percent load level (the level of failure). It was also noted that STA-2B, a skirt test for the filament wound case program tested in 1986, failed at 10,708 microstrain at 129-percent load level. Comparison of the test results indicates variability exists in the failure strains at the critical gage locations. The apparent disparity was investigated by NASA using a fault-tree methodology. Although no specific cause has been identified for this variability, the following items are probable contributors:



- Material property variation between the test articles.
- Residual stresses resulting from assembly, welding, and/or previous use.
- Other skirt-to-skirt variation; geometry, tolerances and strain-gage location.
- Component test not accurately representing the full-skirt configuration.
- An unidentified contributor.
- A combination of the above factors.

Following this investigation, the cost/benefit of proceeding with the test team investigation versus ending the effort was evaluated and the investigation terminated. The following rationale supported this decision.

The test program also included testing with a bracketed test article. The article was tested to the limits of the test support structure (270-percent load level) without a weld failure occurring. A comparison between the two test configurations (with and without the bracket) demonstrated a minimum increase in capability of the bracketed skirt section of 62 percent. This indicates that the addition of the external bracket would return the aft skirt critical weld factor of safety to a value in excess of 2.0. The two tests, performed in the same manner and test configuration, should allow comparable quantitative evaluation of performance. The 62-percent increase in capability mitigates significantly any concerns with the minor variations (<10 percent) in strain levels between component test articles and STA-3 up to 128 percent, and those variations in load capability measured during the entirety of the test series.

The pedigree of flight hardware is assessed following each flight and a statistical pedigree has been established. Evaluation of skirts, following 67 successful launches plus Flight Readiness Firings and pad aborts, has identified no deterioration of the welds as a result of flight loads.

STA-3 sustained 100-percent load for both prelaunch and rebound cases. The initial weld failure occurred at 128 percent with sufficient structural redundancy to allow continued loading to 142 percent. The skirt reacted loads were greater than the design limit for more than 7 minutes after the initial failure.

The flight hardware assessment and loading includes the following:

a. The Mobile Launch Platform (MLP) spherical bearings are now biased radially inward to ensure favorable assembly conditions exist. The support post bushings/bearings have been locked to preclude the undesirable effects of load slip.

b. Each skirt has been instrumented (only one has yet to be included in this data base) to measure the system strains. This has resulted in 52 sets of full-scale strain data from 27 flights. The data correspond well with STA-3 and the component testing. The average peak strain during the SSME thrust buildup is 4181 microstrain with a standard deviation of 381 microstrain. The maximum measured strain was 5072 microstrain (excluding STS-44, S/N 20029 which recorded an apparent strain level of 5488 microstrain due to the Bauschinger effect). The comparable strain from the test programs (including STA-3) at 100-percent load was approximately 5080 microstrain.

c. Variation in on-pad loads, as indicated by MLP instrumentation and verified by the aft skirt strain gage data, is small.

In summary, component test results indicate that the external bracket significantly enhances critical weld factors of safety. In addition to providing substantive quantitative verification of existing analytical techniques, the completed evaluation of the test program results has provided no challenge to or indictment of current flight rationale. The resultant potential benefits from introduction of the bracket are limited. The design change has minimal potential for increasing the Shuttle lift-off wind allowables (and associated probability of launch), as other elements are similarly constraining. The elimination of the Advanced Solid Rocket Motor effort precludes near-term concerns for substantially increased skirt loading. The significant component, subscale and full-scale analysis and test, along with individualized measurements of each aft skirt, provide a level of understanding such that no further concerns exist for a demonstrated 1.28 factor of safety in the critical weld area. Therefore, implementation of the bracket is not planned at this time, and the program plans to change the appropriate specification requirement to reflect this factor of safety to avoid repetitive flight-by-flight waivers.

LOGISTICS AND SUPPORT

Finding #21:
The effort by the NASA logistics organization and its principal contractors has resulted in satisfactory performance. There remain a few problems, such as a tendency towards increased cannibalization, which still require attention.

Recommendation #21:
Every effort should be made to avoid cannibalizations, particularly on critical components such as the SSME and the IAPU.

NASA Response to Recommendation #21:
While there were some increases in cannibalizations in mid-1994, continued management attention has maintained an overall decreasing trend in cannibalizations. Close attention to related indicators will continue. There are currently four spare IAPU's on the shelf at KSC. No IAPU cannibalizations have occurred since 1993.

Finding #22:
The Integrated Logistics Panel (ILP) continues to meet at six-month intervals, usually at the Kennedy Space Center (KSC) or the Marshall Space Flight Center. The ILP serves a valuable coordinating and liaison function for the entire logistics operation. Its personnel complement has been reduced as part of the overall NASA staff cutbacks.

Recommendation #22:
NASA should maintain support of an effective ILP.

NASA Response to Recommendation #22:
Space Shuttle program and project elements continue to support the ILP and related integration activities. Even though personnel cutbacks have been experienced, the ILP is still an effective forum for problem solving, lessons learned, and technical information exchange. In addition, the prime contractors continue to benefit from the exchange of technical data presented at these meetings.

Finding #23:
There is a plan to consolidate all logistics elements at KSC except Spacelab over the next three or four years. This should unify the entire logistics and supply organization. The realignments are intended to eliminate duplication of effort, gain efficiency in support and materially reduce the cost of operation.

Recommendation #23:
Proceed as outlined in the NASA plan.

NASA Response to Recommendation #23:
A single organization consolidating all KSC logistics elements was officially established on April 17, 1995. This new organization integrates logistics functions from the Payload Management and Operations Directorate, the Installation Management and Operations Directorate, the Engineering Development Directorate, and the Shuttle Management and Operations Directorate. This new organization, known as the Logistics Operations Directorate, is now proceeding with internal realignments to eliminate duplication, increase efficiency, and reduce costs while improving customer service.

D. AERONAUTICS

Finding #24:
NASA has entered into a contract with the Tupolev Design Bureau of Russia to support flights of a TU-144 supersonic airplane for a joint U.S./Russian research program. The TU-144 has a questionable safety record, and the particular airplane to be used has not been flown for a number of years. The level of assurance available for this flight project may not be equivalent to that typically associated with NASA's flight research programs.

Recommendation #24:
NASA should assure that all design and safety data and operational characteristics of this vehicle have been fully explored.

NASA Response to Recommendation #24:
The TU-144 Supersonic Flight Research program was developed in consonance with the Gore/Chernomyrdin Agreement on Aeronautics Cooperation of June 1993. The TU-144, as a supersonic testbed aircraft, provides an opportunity to obtain in-flight measurements of information pertinent to future development of a High-Speed Civil Transport aircraft. Given this opportunity, the U.S. aircraft manufacturing industry encouraged NASA, as part of its High Speed Research (HSR) program, to institute an effort that would return a TU-144 aircraft to flight status and conduct a series of flight experiments on the upgraded and instrumented aircraft. A NASA/U.S. industry team has been formulated to lead the effort that will result in the aircraft being returned to a flight status for the completion of six flight experiments.

Prior to contracting for the aircraft refurbishment and instrumentation, a detailed feasibility study was conducted and reported to NASA in December 1993 by Rockwell International Corporation. Also, a series of ground tests and subsystem checkouts were conducted by Tupolev in February 1994 on the aircraft to be upgraded. These tests exercised fuel, hydraulic, and avionics systems and identified line replaceable units that would need to be modified, refurbished, or replaced. TU-144 design and operations data were delivered to the U.S. team as part of these studies and tests. Given favorable results from these feasibility assessments, a contract for the aircraft modification and instrumentation was awarded in August 1994. These program phases are currently in progress. Boeing is the lead U.S. contractor (with McDonnell Douglas sharing a partnership role) and Rockwell International is a subcontractor with responsibility for oversight of aircraft modifications performed by Tupolev.

As part of the aircraft modification phase, the U.S. team requested and was provided with detailed design and safety data required to ensure mission safety and success. In addition, mission planning and flight manifest determinations are being conducted concurrently with the aircraft modification. Tupolev has provided detailed operational data and characteristics obtained during initial TU-144 flight testing. Tupolev and NASA engineers are actively involved in the mission planning activities. Rockwell has hired a full-time engineer at their permanent office in Moscow who serves as an onsite representative at Tupolev and provides regular status reports to the U.S. team. The Rockwell representative has many years of experience in Russian aviation as an employee of the Gromov Flight Research Institute and the Kamov Helicopter Company. He is very knowledgeable about the Russian aircraft industry and the Russian airworthiness process.

Given the international nature of the program and the fact that all of the flights to be conducted under this program will be flown in Russia, it was understood that Russian airworthiness and certification procedures would be utilized to ensure airworthiness of the aircraft. The U.S. industry/NASA TU-144 project team concerned with airworthiness has spent significant effort to understand the Russian processes. A white paper summarizing the U.S. team's understanding of the Russian processes is available in the HSR program office. This understanding was developed during the course of several reviews of the progress of the aircraft modifications and mutual planning of the flight experiments. U.S. personnel have been to Moscow three times between August 1994 and June 1995. Russian personnel have been to the U.S. twice during the same period. The airworthiness process has been a subject of consideration at all of the international interchanges. Prior to the first TU-144 flight, another review of the aircraft modifications is scheduled for September 1995. The U.S. industry/NASA personnel (including safety and mission assurance personnel) are scheduled to attend the Russian flight readiness methodological council meeting in January 1996.

Detailed review of results from the feasibility studies, ground and system checks, aircraft modification reviews, mission planning, and the flight readiness methodological council meeting, all represent the effort that the U.S. industry/NASA team will expend toward ensuring that all design and safety data and operational characteristics of the aircraft have been fully explored. This is evidenced by the deletion of the supersonic boom experiment because of unresolved issues in flight operations, flight safety, and cost.

Finding #25:
Wind shear encounters, while infrequent, constitute a highly significant aviation hazard that has been a causal factor in major crashes. A joint NASA/Federal Aviation Administration (FAA)

Airborne Wind Shear Sensor Program has developed methods, already being implemented, for providing timely warning to aircraft in danger of encountering such atmospheric conditions.

Recommendation #25:
Continue research relating to wind shear and other aircraft-threatening phenomena, such as wake vortices, and the transfer of related technologies to users.

NASA Response to Recommendation #25:
NASA's Windshear program is now complete. The results of this successful wind-shear technology program were adopted by the avionics manufacturers for their development into safety technology for transport aircraft. One manufacturer, AlliedSignal, provided Continental Airlines, one of their customers, with their Model RDR-4D system. This is a combined weather radar and wind-shear radar. It was first flown in commercial service in December 1994. With the completion of the wind-shear program, NASA's expertise and facilities will be applied to the challenges posed by safely increasing the airport traffic capacity and especially the issues associated with wind-vortex encounters. The research consists of identifying and mathematically modeling wake vortices using computational fluid dynamics, existing empirical models and data from required wind tunnel and flight tests, developing and demonstrating a sensor to reveal the hazard to the flight crew, and validating a total system at a Center/Terminal Radar Approach Control (TRACON) Automation System (CTAS) field test site. Much of the technology and approach in this area is enabled by the previously successful development of wind-shear models and sensors.

Finding #26:
NASA has a coordinated program of tire research operating from the Langley Research and Dryden Flight Research Centers. This program has the capability to provide significant safety improvements for present and future aircraft and spacecraft.

Recommendation #26:
In addition to supporting the Space Shuttle and other research programs such as the High Speed Civil Transport, NASA should continue to emphasize and transfer lessons learned in the tire research effort to all segments of the user community.

NASA Response to Recommendation #26:
The CV-990 Landing System Research Aircraft (LSRA) project operated by Dryden Flight Research Center (DFRC) has been instrumental in defining Shuttle orbiter main gear tire performance. This program has been completed. Test results have been provided to the Society of Automotive Engineers (SAE), Boeing, Northrop, McDonnell Douglas, and Canadair. Unanimous agreement exists between Government agencies, the tire industry, and academia that this test facility is unique and supplies, in many areas, the highest fidelity in tire and landing gear testing ever achieved.

NASA is working with the FAA, Canadair, The Canadian Joint Aviation Authority, and others on winter runway friction issues in a proposed 5-year program. This program involves braking test runs with NASA's B-737, B-757, and CV-990 LSRA, together with several different ground friction measuring vehicles and parametric studies, using Langley's Aircraft Landing Dynamics Facility. Results of this program will have a direct impact on not only solving runway friction and airport congestion problems, but also helping industry achieve improved tire designs, better chemical treatments for snow and ice, and runway surfaces that minimize adverse weather effects. Flight-crew recognition of less than acceptable reported runway friction conditions, prior to the go/no-go or the land/go around decision point, is one of the near-term goals.

Finding #27:
The Dryden Flight Research Center (DFRC) has completed a demonstration of the concept of a Propulsion Controlled Aircraft (PCA) system using an F-15 aircraft flight test and an MD-11 simulator demonstration. This system permits an aircraft to be guided to a landing in an emergency using only thrust for flight path control. DFRC is now exploring a joint program with industry to extend the demonstration to a flight test on a large commercial aircraft. Although the PCA concept has been proved, the pilot control interface aspects of the design have yet to be systematically addressed.

Recommendation #27:
Any flight test program on a large commercial aircraft should include a strong focus on selecting the optimum pilot control interface for the system.

NASA Response to Recommendation #27:
Aircraft pilot interface is critical when dealing with emergency situations. Therefore, the PCA project has conducted simulator studies that addressed the pilot interface with the PCA system. A comprehensive study in the Ames Advanced Concepts Flight Simulator looked at inputting PCA commands using modern sidestick controllers and autopilot glare shield control panel (GSCP) knobs (pitch and heading/track). Six pilots flew 100 approaches with various levels of turbulence. Pilot ratings, touchdown dispersions, and pilot opinions all showed a preference for using the GSCP knobs. The slow response of the PCA is more consistent with the autopilot response that is commanded by the GSCP controllers. It was shown that in an emergency situation, the use of sidestick controller to command the slow PCA system could result in a Pilot Induced Oscillation. The pilots will be specifically requested to address aircraft pilot interfaces during the upcoming MD-11 PCA evaluation flights.

Finding #28:
The range safety policy for Unmanned Aerial Vehicle (UAV) operations within the Edwards Air Force Base range worked when the Perseus program suffered an in-flight failure. Range safety for Perseus flights outside of the controlled airspace at Edwards has yet to be addressed.

Recommendation #28:
Consideration should now be given to establishing a UAV policy to cover Perseus flights conducted outside of controlled airspace at Edwards.

NASA Response to Recommendation #28:
The use of non-Edwards controlled airspace falls under the regulation of the FAA. The Office of Aeronautics, through the Environmental Research Aircraft and Sensor Technology (ERAST) program, has for the past 2 years been participating in workshops sponsored by the FAA for the

purpose of developing Federal Aviation Regulations needed to establish the appropriate oversight of Remotely Piloted Aircraft flight operations in the National Airspace System. Draft Advisory Circulars have been prepared and are currently undergoing legal review. The ERAST program will continue to work with the FAA toward implementing the needed regulations.

E. OTHER

Finding #29:
The Simplified Aid for EVA Rescue (SAFER) was successfully flight tested on the STS-64 mission. Although designed as a rescue device for an astronaut who becomes untethered, SAFER has demonstrated its potential to assist in other safety-critical situations such as contingency EVAs. Five SAFER flight units have been ordered. Plans are to deploy them on Mir and Space Station as well as to carry them on the Space Shuttle only when an EVA is planned.

Recommendation #29:
Once the flight units are available, NASA should consider routinely flying SAFER units on all Space Shuttle missions which do not have severe weight limitations. This will permit them to be used for those contingency EVAs in which safety can be improved
by giving crew members the capability to translate to the location of a problem to make an inspection or effect a repair.

NASA Response to Recommendation #29:
NASA has considered routinely flying SAFER units on all Space Shuttle missions which do not have severe weight limitations and has decided that it is not required.

SAFER was specifically designed to be used to rescue an EVA crewmember who had become inadvertently detached from a structure under the circumstances where the Shuttle could not credibly effect a rescue (for example, during Space Station operations when the Shuttle is either not at the Station or is docked to it). As such, it is classified as an "emergency" device and only needs to be single-string (i.e., zero-fault tolerant).

SAFER is not required for other (operational) EVA's. All known, credible, contingency EVA's can be safely accomplished without it. There currently exists an EVA method to get to the External Tank (ET) umbilical doors located on the Orbiter without SAFER, for which each EVA crewmember is briefed prior to flight.

Furthermore, the cost of making SAFER operational on all Shuttle flights would be high. To be used as other than an emergency device, significant redesign would be required to make it at least single-fault tolerant. SAFER cannot be stowed on the Primary Life Support Subsystem in the airlock; therefore, special stowage would be required on each flight. Flying two SAFER units on each flight would require stowage for about 8 cubic feet and 200 pounds. Additional EVA training would also be required each time SAFER is flown, regardless of whether or not it is planned to be used.

Given the above reasons including the fact that all known, credible, contingency EVA's can be safely accomplished without SAFER, NASA believes that implementing this recommendation is not appropriate at this time.

Finding #30:
NASA has established a Software Process Action Team (SPAT)to review and develop plans for addressing the software concerns that have been raised within NASA and by several review boards including the National Research Council and the Aerospace Safety Advisory Panel. While NASA has extensive procedures for addressing software issues in some arenas, these issues have not received uniform recognition of their importance throughout the Agency.

Recommendation #30:
NASA should ensure that computer software issues are given high priority throughout the agency and that those addressing these issues are given the support needed to produce adequate ways of dealing with them. The creation of the SPAT was an important initial step toward dealing with complex safety critical problems, but much more needs to be done.

NASA Response to Recommendation #30
NASA fully agrees with the recommendation that computer software issues must be given a high priority throughout the Agency. Recent actions taken and decisions made in the Zero-Base Review operating guidelines supports the NASA senior managers' high priority for the critical and complex software issues. NASA offered a pilot Software Program/Project Management course in March 1995. This training exhibits a priority of software issues within NASA. The follow-on "Software Acquisition" training course will be provided in August 1995 to NASA managers with significant software in their projects.

The Independent Verification and Validation (IV&V) Center of Excellence addresses complex critical software issues across NASA with the Software Improvement Initiative and IV&V on projects. The Agencywide Software Improvement program and the Agencywide Software Working Group will coordinate software issues that affect the Agency. The Software Working Group Charter gives each member the responsibility and authority to represent the software needs of their respective Center. The consolidation of IV&V projects to the NASA facility aids in addressing software issues with uniform recognition of importance across the Agency.

The Program Office representation to the Software Working Group has been strengthened. The Software Process Action Team merged with an existing working group to formulate the current Software Working Group, with cochairs from the IV&V Center of Excellence and the Chief Engineer's Office. Active Program Office support and participation in the Software Working Group would better accomplish the ASAP's Recommendation #30.

Finding #31:
There were several in-flight and ground-based episodes in which astronauts developed adverse reactions to substances used in human experiments. Although the researchers guiding these experiments submit the protocols to standard Institutional Review Board (IRB) process, there is no independent oversight of the safety of human experiments within NASA.

Recommendation #31:
NASA should provide independent oversight of human experimentation by establishing a review process in addition to the standard IRB and ensuring that the Space Shuttle and Space Station systems requirements provide sufficient equipment, staffing and training to react appropriately to any problems which might be experienced.

NASA Response to Recommendation #31:
NASA has disbanded the former Human Research Policy and Procedures Committee (HRPCC) and replaced it with an IRB. This IRB has a broader representation from operationally oriented people and physicians in addition to the researchers formerly constituting the HRPCC. Also, there is a safety representative from the JSC Office of Safety, Reliability, and Quality Assurance that participates as a member of the new IRB. NASA believes that the broader representation, combined with the continued presence of the safety representative, provides the appropriate level of safety oversight for this review process that is being sought by the ASAP. This also corrects previous shortcomings in the review process. The oversight processes of the JSC Office of Safety, Reliability, and Quality Assurance and the International Space Station Independent Assessment Panel have been designed to assure that requirements deficiencies related to equipment, staffing, and training that may exist in the Space Shuttle and Space Station programs are identified and dealt with appropriately.

Finding #32:
The number of reports submitted to the Aviation Safety Reporting System (ASRS) has nearly doubled since 1988 and has consistently been above the levels projected when the system was started. In these same years, budgetary resources have remained flat so that, even with significant productivity increases, the portion of incidents that receive detailed analysis has declined. In addition, ASRS has not been able to develop cost effective electronic dissemination of advisories or a program of educational outreach to expand use of ASRS by the aviation community, both of which would be significant safety enhancements.

Recommendation #32:
NASA and the FAA should restore the full capability of analysis, interpretation, and dissemination of the ASRS and promote electronic dissemination and expanded educational outreach.

NASA Response to Recommendation #32:
In 1993, the FAA asked the National Academy of Public Administration (NAPA) to review this program and to recommend how to improve and evolve the system. In August 1994, NAPA published their report concluding that ASRS is "a credible, resilient and worthwhile program" and cited it as a model for interagency cooperation. Recommendations from this report led to the formation of an FAA/NASA interagency team to develop an action plan that was submitted in November 1994. After several reviews, the action plan was approved. The FAA funded initial work in February 1995 and plans to fund to completion in FY 1996. This program consists of the following four major elements:

(1) An increase in effort to cover the growth in the number of reports submitted and to expand the number of "call back" validations conducted.

(2) A modernization program to improve the performance of the computer systems supporting data input and analysis. The evaluation of artificial-intelligence techniques to provide screening and sampling as well as the use of statistical techniques (These techniques should substantially reduce the work required to perform the analysis for input). A modernization program is expected to yield electronic distribution of derivative data in the form of CD/ROM and Internet distribution.

(3) Initiation of an educational and promotional program directed at members of the industrial community, as well as the FAA analysts whose work can be enhanced by access to these data. The effort will include the electronic distribution of
ASRS products including CALLBACK and DIRECTLINE.

(4) The expansion of the ASRS to solicit input from a wider range of the flight community, including cabin attendants, mechanics, and technicians.

NASA is already conducting activity to improve the ASRS including the issues raised by the findings and recommendations identified by the ASAP.

Finding #33:
For many years, NACA and NASA aeronautical research and flight safety benefitted from the advise and counsel provided by an advisory group of aircraft operations specialists consisting of representatives from civil and military aviation and manufacturers of aircraft, engines, and accessories as well as NACA/NASA personnel.

Recommendation #33:
NASA should restore the previous capacity to capture the operational experience it found useful in improving its research focus and flight safety.

NASA Response to Recommendation #33:
The Office of Aeronautics, in consultation with DFRC and others, will assess potential changes to the current Aeronautics Advisory Committee's subcommittee structure that would provide improved advice and council on aircraft safety and operating problems.

APPENDIX C

NASA AEROSPACE SAFETY ADVISORY PANEL ACTIVITIES FEBRUARY–DECEMBER 1995

FEBRUARY

1–3	STS-63 Mission Meetings and Launch, Kennedy Space Center
7–8	Space Shuttle Mir Briefing, Johnson Space Center

MARCH

15–17	Processing Operations Review, Kennedy Space Center
16	Testimony before the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives' hearing on "The Outside Opinion: NASA Restructuring Space Shuttle/ Space Station Reusable Launch Vehicles", Washington, DC
22	Panel Plenary Session, NASA Headquarters
23	Aerospace Safety Advisory Panel Annual Meeting, NASA Headquarters

APRIL

11	Letter to Chairman Sensenbrenner responding to followup questions from March 16 hearing
12	Space Shuttle Program Discussions with General Accounting Office, NASA Headquarters
19–20	Review of Aeronautics and Human Factors Safety Programs, Ames Research Center

MAY

8	Space Shuttle Downsizing Review, NASA Headquarters
9–11	Intercenter Aircraft Operations Panel Meeting, Lewis Research Center
15	Letter Report to Administrator on Panel Review of Space Shuttle Management Independent Review , NASA Federal Laboratory Review, and Zero Base Review
16	Testimony before Subcommittee on Science and Technology and Space, US Senate's hearing on "Space Shuttle and Reusable Launch Vehicle Programs"
24–25	Review of Space Shuttle Main Engine and Center Safety Programs, Marshall Space Flight Center

JUNE

2	STS-71 Flight Readiness Review, Kennedy Space Center
13	Review of Redesign Solid Rocket Motor Program, Thiokol Corporation
14–15	Review of the External Tank Activities, Michoud Assembly Facility
21–23	STS-71 Mission Meetings and Launch, Kennedy Space Center
28	Review of Space Shuttle Main Engine Turbopump Nozzle Cracks, Rocketdyne

JULY

10	Space Shuttle Main Engine Turbopump Nozzle Cracks Interview, Dallas
11–12	Review of Space Shuttle Main Engine Turbopump Program, Rocketdyne
13	Review of Aeronautics Safety Programs, Langley Research Center
19–20	Review of Space Shuttle and International Space Station Safety Programs, Johnson Space Center
19	Panel Plenary Session, Johnson Space Center
26	Review Meeting of GAO Report on Space Shuttle in Support of Space Station, NASA Headquarters

AUGUST

3–4	Software Review, Johnson Space Center
9	Interview on Yellow Creek's Advanced Solid Rocket Motor Program, NASA Headquarters
10	Space Shuttle Restructuring Meeting, NASA Headquarters
31	Space Shuttle Main Engine High Pressure Fuel Turbopump Assessment Team Report to the NASA Administrator

SEPTEMBER

22	Review of Space Shuttle Safety Operations in preparation of September 27 Testimony, Kennedy Space Center
27	Testimony before the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives' hearing on "The Space Shuttle Program in Transition: Keeping Safety Paramount"

OCTOBER

16	Panel Plenary Session, Lancaster, CA
17	Review of Aerospace Projects, Dryden Flight Research Center
18	Review of Space Shuttle Main Engine Blocks I and II Programs, Rocketdyne
18	Review of Space Station Electric Power System, Rocketdyne
19	Review of Space Shuttle Orbiter Program, Rockwell
19	Review of the Information Technology and Software, Ames Research Center
24	Letter to Chairman Sensenbrenner responding to folloup questions from September 27 hearing on "The Space Shuttle Program in Transition: Keeping Safety Paramount"

NOVEMBER

1–2	Integrated Logistics Panel Meeting, Kennedy Space Center
28–29	Panel Plenary Session, NASA Headquarters
28	Review of Safety and Mission Assurance Restructuring, NASA Headquarters
29	Review of Space Station Security Concerns, NASA Headquarters
29	Review of Space Shuttle Restructuring, NASA Headquarters

DECEMBER

14	Review of Space Shuttle Restructuring and Privatization, NASA Headquarters

National Aeronautics and
Space Administration

For Further Information Please Contact:

Aerospace Safety Advisory Panel
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