II. SPACE SHUTTLE MANAGEMENT

1. ORGANIZATION

ASAP FINDING AND RECOMMENDATION: The Panel finds the problem of worker morale, especially at KSC, is of special concern. This is a classic problem of organizational and inspirational leadership that cannot be solved simply by changing institutional structures. The Panel recommends that NASA's top management, including the Administrator, Associate Administrator for Space Flight, the STS Director, and the Center Directors, take the lead in recapturing or rebuilding a spirit of mutual respect and trust at all levels. (p. 17, 66)

NASA RESPONSE: NASA and SPC management have instituted monthly meetings at the Orbiter Processing Facility (OPF) which feature members of top management, e.g., General McCartney, in direct interchange with employees. These forums provide the opportunity for the workers to get the "straight story" firsthand--viewed as a key ingredient in improving worker morale. There has also been an increased emphasis on publicizing good performance via in-house printed media. Widespread recognition of achievement and an expanded employee suggestion program are also aimed to improve morale.

NASA's Manned Flight Awareness Program - focusing on the government, contractor, military, and subcontractor employees working together as a team to achieve and maintain astronaut safety and mission success - was reinstituted with an honoree event at KSC in December 1986. This program, along with increased astronaut visits to KSC, plus other NASA centers and contractor facilities as well, is another measure being employed to rebuild team spirit. This participation promotes a personal bond between them and the processing team, reinforcing the awareness of the criticality of performance. The most recent honoree event was held in May 1987, in Washington, DC, and was a huge success. More than 600 people, including 14 astronauts, were in attendance. The next event is scheduled to be held at MSFC in October 1987.

ASAP FINDING AND RECOMMENDATION: The Panel notes that recapturing NASA's self-confidence in managing the shuttle program is crucial to success and requires NASA's leadership to keep in perspective the activities of the many advisory groups, task forces, and panels that have been created in the aftermath of the Challenger accident. NASA has the ultimate responsibility and authority to manage NSTS after giving appropriate consideration to the findings and recommendations of oversight groups. The individuals involved in these review panels, as well as Members of Congress, should recognize that excessive reliance by NASA management on external and internal review groups runs the real risk of destroying NASA's initiative and self-confidence, key elements of success in any human endeavor. (p. 17-18)

NASA RESPONSE: While we appreciate the assistance which we have obtained from the various review groups, we recognize that ultimately the NASA managers and the NASA team are responsible for managing NSTS and making it work. We fully agree with and appreciate the ASAP comment that NASA is accountable for the success of the program.

2. RESEARCH AND DEVELOPMENT VS. OPERATIONAL STATUS

ASAP FINDING AND RECOMMENDATION: NASA, in collaboration with the SPC, should make a concerted push to achieve greater consolidation and upgrading of STS information systems, particularly those related to configuration management and launch procedures. For example, the Problem Reporting and Corrective Action System (PRACA) is not programmed to identify big problems and trends in a timely manner. An improvement in management information will contribute directly to more reliable and predictable launch processing. (p. 19, 20)

NASA RESPONSE: NASA and the SPC are making a major effort to upgrade and integrate the STS information systems related to configuration management and launch processing support. NASA has requested a significant increase in the budget for this effort, extending from FY 1988 through FY 1992, and initiated the activity through the SPC. The PRACA and other processing-related data systems will be improved individually. These and several other processing-related information systems will be interconnected and integrated into an overall Shuttle Processing Data Management System (SPDMS) #II. SPDMS II will provide the hardware, software, data base and computer-to-computer communications for the accurate, efficient and safe collection, manipulation, dissemination and interchange of shuttle ground processing technical and management information. It will also be interconnected with shuttle information systems at other field centers, such as the Program Compliance Assurance and Status System (PCASS) of the System Integrity Assurance Program (SIAP) at JSC. SPDMS II will be initiated in 1988 with initial emphasis on the Operations & Maintenance Requirements & Specifications Document (OMRSD) closed-loop accounting related to returning to flight status. Additionally, SRM&QA is publishing on a regular basis a Significant Problem Report (SPR) which is widely distributed and statused. Other improvements are scheduled to follow which will lead to system maturity.

3. HUMAN RESOURCES

ASAP FINDING AND RECOMMENDATION: The Panel finds that recent layoffs by the SPC of a large number of workers at KSC to accommodate the STS standdown have lost skilled employees who will be needed in 1987 as preparations intensify for a resumption of space shuttle launches. The Panel recommends that the SPC should identify these losses and begin now, locating, recruiting, training and retraining the necessary persons with the skills to support all aspects of these preparations, including modifications to the orbiter and other STS systems that will be identified by ongoing NASA reviews. (p. 21)

NASA RESPONSE: The challenge of restaffing in order to support the first launch in 1988 is well recognized. Plans call for acquiring additional personnel, training or retraining them as the workload dictates, and recertifying them in accordance with job requirements.

During layoff activities, consideration was given to assure the maintenance of appropriate supervisory ratios to support the standdown period work and to retain key personnel for future requirements. Additionally, there is heavy emphasis being placed on reactivation training. This program addresses training for technicians and inspectors in the operational processing areas. NASA feels that the SPC has retained an excellent base on which to build. In addition, it should be noted that to date, in fiscal year 1987, an additional 600 SPC workers have been hired.

ASAP FINDING AND RECOMMENDATION: The Panel finds that uncertainty among SPC workers at KSC as to job security has undermined morale and other management efforts to improve communication and worker participation in launch processing decisions. It is recommended that top SPC and NASA management should personally act to eliminate this uncertainty by dispelling rumors when they arise and leveling with workers as to their future job prospects. (p. 21, 22)

NASA RESPONSE: The post STS 51-L worker environment can be described as one of great uncertainty. This situation was the root cause of morale problems and continued through the phases of the President's Commission, Congressional Committee, NASA Team, and panel investigations, and certainly through periods of workforce reduction. As the NASA organizational and personnel changes have taken place, redesigns have been identified, hardware testing results have been released, work content has been identified, and worker morale has improved.

Both NASA and SPC management policy is to notify, as soon as possible, the workforce of specific directions, actions, or decisions which affect them. To this end, such initiatives as OPF meetings which include members of top management (e.g., General McCartney or E. Douglas Sargent) in direct interchange with the workers have been started.

ASAP FINDING AND RECOMMENDATION: The SPC is expanding training opportunities for workers, but often this training is not focused on meeting the needs of individual workers. Training opportunities need to be linked more explicitly to expanding worker skills to permit longer term career progression. (p. 22)

NASA RESPONSE: A concerted effort is underway to provide training that is tailored to the needs of individual workers. Certification and recertification training, offsite training, and tuition assistance programs are available to the workforce. Cross-training opportunities for numerous individuals, in various disciplines and job assignments have been made available. Since June 1986, the number of workers attending training has risen significantly due to SPC management's increased emphasis to upgrade skills needed to perform critical tasks and processes. To assure that training opportunities are geared towards expanding worker skills, NASA/element contractors/and SPC senior management review training and certification program activities on a weekly basis.

ASAP FINDING AND RECOMMENDATION: The Panel finds there still appears to be some difficulties in communication between top SPC and NASA managers with floor supervisors and workers. The paperwork burden remains heavy. Instructions regarding specific processing operations are often inaccurate or incomplete, leading to inefficient scheduling and potentially to safety problems. It is recommended that top managers need to communicate more directly with workers involved in launch processing to provide a clear sense of mission and direction, as well as to benefit from employee initiatives and suggestions. (p. 22)

NASA RESPONSE: NASA and the SPC have instituted a program of frequent periodic meetings with all levels to improve communications and morale. These meetings rotate speakers from the KSC Center Director, division directors, astronauts, SPC corporate officers, and middle managers for audiences of engineers, planners, floor managers and technicians. They are formatted to promote recognition, respect, understanding and cooperation through all levels and throughout the development and supporting channels of the program. The SPC has also initiated weekly meetings between personnel officers and all directorates, including representatives of salaried, hourly, engineering and floor worker employees. A suggestion box system and quality circles program have been set up to promote communication in the upward and lateral directions. The written forms of communications such as the operations maintenance instructions and test procedures, have also been thoroughly reviewed and are being improved through revisions. The specific procedures dealing with criticality 1 items are also being reviewed and endorsed by the respective hardware development organization. The paperwork burden is being relieved by computer automation systems and by increasing the manpower that support the data flow systems, planning, and scheduling activities. In addition, an independent NASA Safety Reporting System (NSRS) has been implemented for STS.

4. SCHEDULE VS. BUDGET

ASAP COMMENT: Panel members have believed for some time that the space shuttle program has been underfunded and that these shortfalls, in turn, contributed to a Space Transportation System that was incapable of meeting the launch schedule NASA projected prior to the Challenger accident. The present review of Failure Modes and Effects Analysis (FMEAs) and Critical Items List (CILs) will likely generate a number of modifications to the Space Transportation System that will have to be accomplished prior to resuming a flight schedule. It is essential that budgetary concerns not unduly limit the designs and modifications that are needed from a safety and reliability perspective. If funds are not available to accomplish this work due to budgetary ceilings or other fiscal limits, the only acceptable alternative is to stretch out the schedule. (p. 22, 23)

NASA RESPONSE: Safety will not be compromised regardless of whatever budgetary or fiscal constraints might be imposed. If adequate funds are not available, we will make these facts known and make whatever adjustments are necessary to achieve the earliest safe Shuttle flight and ensure that we maintain a realistic flight schedule. We are concerned that stretch outs not only result in increased costs but could actually increase the chances of failure because of the loss of recent experience in operating the system and the potential loss of trained personnel.

III. SPACE SHUTTLE SYSTEMS

1. SOLID ROCKET BOOSTER

ASAP COMMENT - NOZZLE-TO-CASE JOINT: The redesign of this joint incorporates 100 radial bolts, each with a "Stat-O-Seal" under its head. The bolts are intended to reduce the relative motion between the housing and the aft dome. The new design also includes a third (wiper) seal and a second test port, as well as circumferential flow baffles in the insulation.

The addition of the bolts adds multiple potential leak paths and residual stresses in the fixed housing that can reduce the reliability of the joint. The wiper seal bears on insulation rather than on metal. This could limit the pressure that can be employed during leak testing of the assembly.

There are a number of unresolved design questions at this time. Among them are the possibility of hot gas jet impingement of circumferential flow of such gas that could result from an insulation debond, and the ability to disassemble the nozzle from the case without damage to the insulation. Two alternate designs are being considered. One incorporates a metal thermaloc u-seal which maintains contact with the nozzle fixed housing and case aft dome during pressurization. The other concept is to insulate over the case-to-nozzle joint making it a factory joint. This design requires a new "field type" joint in the aft segment case and a redesign of the aft propellant grain. (p. 29)

NASA RESPONSE: The addition of the bolts does add multiple potential secondary leak paths. The bolt stat-o-seal concept, which the igniter/adapter incorporates, has been extremely reliable (i.e., no detectable failures in 57 firings). Hence, the stat-o-seals should not create a joint reliability problem. The fixed housing bolt holes also cause some local stress risers which the RSRM analyses must consider. Properly designed radial bolt holes maintain required factors of safety that will be verified by test.

The reference to the wiper as a "seal" is misleading as its design function is as a wiper to prevent the insulation joint adhesive from extruding into the primary o-ring groove. The combination of the wiper and cured joint adhesive will provide the medium to allow seating of the primary o-ring in the proper direction following the high pressure leak check between the primary and secondary o-rings. The allowable pressure in the wiper to primary o-ring cavity and its effects on the joint adhesive and joint insulation is being assessed both analytically and in Nozzle Joint Assembly Demonstration (NJAD) test article.

Both the jet impingement and circumferential flow issues are under intense scrutiny from two areas. The first area being analytical assessment of the affects of varying flaw sizes and types. As part of this analytical effort, the structural pressurization effects on joint free volumes and flaw sizes are being coupled to the flow/thermal analysis. Another major change in the flow/thermal analysis is the program decision to use the QM-4 nozzle vector duty cycle rather than the combined worst case envelope. The worst case envelope previously used represents the single worst vector degree angle from every potential mission scenario and not a single mission scenario. The analytical model predictions are also being calibrated through a subscale motor test program currently underway.

The second area under scrutiny is the characterization and probability assessment of potential flaws. This is being fed back into the flow/thermal analysis to establish the acceptability determined by meeting either design criteria or fail safe criteria. A key article in potential flaw assessment is the full-scale nozzle joint assembly article currently in work.

The ability to disassemble the nozzle without damage to the insulation is not a requirement. It is a consideration, but not at the expense of reliability and flight safety. The disassembly characteristics are currently being evaluated as part of the NJAD testing.

Reference was made to two alternate design concepts. The first, the thermaloc u-seal, is being actively pursued and will be tested in NJES-5. The second, the case/nozzle factory joint concept, is a concept and is not currently being actively worked. A third concept, a vented interlock insulation with the current baseline metal parts, is being evaluated in subscale test motors. Full-scale mold tooling is inhouse and a checkout fabrication is planned.

ASAP COMMENT - NOZZLE SYSTEM - The existing nozzle seals have performed adequately to date. The new design requirement for redundant and verifiable seals has, however, resulted in a complete redesign of all these seals. All such nozzle internal joints (there are five) are being revised to contain two seals with an intervening seal test port. All of these joints act to close the joint under operating load conditions except for the "number five" joint which acts to close the inboard seal and open the outboard seal in operation.

In addition to internal nozzle joint seal design changes, the ply lay-up angles of the ablator material on the several rings of the nozzle structure are being changed to reduce, if not eliminate, the pocketing erosion that has been experienced in the past. The cure cycle for the graphite composite material employed may have to be changed in order to limit erosion and charring.

The changes being made are many and complex and to validate their suitability requires full-scale, full-duration, hot-firing tests. The number of such tests required to establish confidence in the reliability of these changes will be large and has yet to be established.

Thus, the categorical application of the requirement that all seals be redundant and verifiable to all SRB joints may affect cost, schedule, and inspection procedures and may also reduce inherent reliability. (p. 29, 30)

NASA RESPONSE: The Aerospace Safety Advisory Panel's concern regarding the magnitude of changes approved for the RSRM nozzle has been considered and recently additional full-scale motors have been added to the static test program. To validate the suitability of the RSRM nozzle, it is planned to hot-fire full-scale, redesigned nozzles in a series of RSRM static tests beginning with DM-8, which will include many of the redesigned items. Those not incorporated into DM-8 will be into DM-9 and subsequent. In addition, detailed 2-D and 3-D analyses will support the design selection and validation process, as will subscale laboratory testing.

The following table details the RSRM nozzle features and point of full scale static test incorporation:

POINT OF INCORPORATION OF NOZZLE DESIGN CHANGES

FEATURE	DM-8	DM-9 AND SUBSEQUENT
REDUNDANT AND VERIFIABLE SEALS		
. NEW FIXED HOUSING WITH RADIAL BOLTS AND DUAL SEALS AND LEAK CHECK PORT		X
FEATURE	DM-8	DM-9 AND SUBSEQUENT
. NEW NOSE INLET HOUSING WITH DUAL SEALS, LEAK CHECK PORT, THICKER WEB, MORE MASSIVE STIFFENER RIB AND BONDING SURFACE IMPROVEMENTS (PHOSPHORIC ACID ANODIZATION AND ADHESIVE PRIMER)		X
. MODIFIED THROAT INLET HOUSING WITH DUAL SEALS		X
. MODIFIED FORWARD EXIT CONE HOUSING WITH DUAL SEALS AND LEAK CHECK PORTS (FORE AND AFT)	X	
. AFT EXIT CONE HOUSING BONDING SURFACE IMPROVEMENTS (PAA AND ADHESIVE PRIMER)		X
. REDESIGNED FIXED HOUSING INSULATOR TO COMPLEMENT BONDED CASE TO NOZZLE JOINT	X	
. THICKENED STRUCTURAL SUPPORT OUTER BOOT RING	X	
. THICKENED COWL LINER	X	
. REVISED TAPE WRAP PLY ANGLES IN FORWARD NOSE RING, AFT INLET RING AND THROAT RING	X	
. THICKENED AFT EXIT CONE LINER	X	
. IMPROVED BONDING AND ASSEMBLY PROCESSES		X
. REPLACEMENT OF EA913 WITH EA913 NA		X
. REDESIGNED NOZZLE PLUG	X	

ASAP COMMENT - IGNITER SYSTEM: The thickness of the igniter aft dome case will be increased to eliminate a negative margin of safety. This redesign is the only change that has been deemed mandatory for first reflight by NASA.

In the past, the igniter joint has exhibited primary seal erosion and blowby during the full-scale, hot firings. Test should be made to identify the joint leak paths so corrective action can be taken. (p. 30)

NASA RESPONSE: In considering the subject of erosion/blowby in the igniter during full-scale firings, it is important to identify that the DM-6 igniter experienced the only seal damage (erosion). Soot blowby was identified on the following igniters during post-flight inspection; SRM-11B, SRM-13B, SRM-17A, SRM-17B, SRM-18A.

Engineering determined the cause of the blowby and erosion to be an overfill condition in the igniter inner gask-o-seals. The condition was not detected by the seal vendor due to a faulty inspection method. It was determined that the gask-o-seals used in the above igniters were out of specification tolerance.

The problem became evident on 24 April 1985 when DM-6 igniter was disassembled. This is documented in TWR-14999 (significant program report DR4-4/43).

The following actions have been taken:

- Vendor's inspection method has been corrected and verified.
- All overfill gask-o-seals inhouse were sent to the vendor for refurbishment (new molded seals), and
- Overfill gask-o-seals already installed in motors were re-torqued per TWA-769 to ensure bolt torque relaxation did not occur.

Additionally, properly manufactured gask-o-seals will be evaluated in each of the static tests in the RSRM program.

ASAP FINDINGS AND RECOMMENDATIONS - SRB JOINT REDESIGNS: The Panel recommends that a more complete definition of the certification test program be required in order to determine its adequacy. The Panel also recommends that a concerted effort be made to include additional full-scale, hot firing tests in the final test program plan so as to reduce the possibility of undiscovered weaknesses. Further that during the first year of resumed shuttle flights, the SRBs be heavily instrumented to obtain both structural and performance data and that these data be considered as part of the certification program.

To attain a SRB design with a higher margin of safety for the long-term use with the shuttle, it is suggested that NASA proceed with the development of the "Langley" design (or its equivalent) for the case field joint and the "Hercules" design (or its equivalent) for the nozzle-to-case joint in an aggressive effort. (p. 32, 33)

NASA RESPONSE: The certification of the RSRM is detailed in TWR-15723 (Vol I-X), Development and Verification Plan for the RSRM. This plan includes a number of full-scale, hot fire tests of the RSRM and includes a full-scale motor test at both high and low temperature extremes with applied side loads. The Design, Development, Test & Evaluation (DDT&E) Flight (6) are an integral part of the RSRM certification process. These flights will contain 215 channels of Development Flight Instrumentation (DFI), and three channels of Operational Flight Instrumentation (OFI) for the SRM.

MTI has issued a subcontract to Lockheed to evaluate and analyze alternate joint concepts, including the "Langley" design. Steel billets have also been put on order as schedule protection for this activity. This effort, including reporting, will be completed late this year. Implementation of this or other Block II concepts is dependent upon overall NASA plans for future shuttle development.

ASAP FINDINGS AND RECOMMENDATIONS - SRB TEST FIRING ATTITUDE: The Panel recommends and agrees with the decision to conduct the hot-firing tests of the SRB in the horizontal attitude. The Panel notes that, despite the array of subscale, large diameter, and full-scale tests contemplated, there is no way to ensure that the tests encompass all possible loading conditions and assembly differences. The Panel strongly urges, therefore, that during the first year of resumed STS flights, the SRB's be heavily instrumented to obtain structural and performance data and that these data be considered to be part of the certification program. (P. 34)

NASA RESPONSE: OFI and DFI on the RSRMs for the first (6) flights will include 218 MTI requested measurements per motor (436 per flight), plus an additional 39 MSFC measurements per flight. In addition, there are 108 DFI and 24 heaters sensor measurements recorded prior to lift off. The following table identifies the currently planned OFI, DFI, GFI instrumentation. This is approximately (3) times the measurements installed on the motors for the first (6) flights (STS-1 through STS-6). At least (3) OFI measurements per motor will always be installed to provide actual motor performance. Some of the presently installed DFI measurements may be converted to OFI indefinitely on subsequent flights after the development flights. Most of the DFI will be installed to obtain the thermal and structural loads occurring from flight aerodynamics and aerothermal loads. More valid SRM data should be obtained from these flights over earlier flights since the majority of these measurements were requested and located by MTI to coincide with static test instrumentation.

DEVELOPMENT FLIGHT INSTRUMENTATION (DFI) RSRM 1-6 MEASUREMENT

QUANTITY		MEASUREMENT
LH	RH	FORWARD SKIRT
3	3	Accelerometers ±10g
		FORWARD SEGMENT
3	3	Pressure 0-1000 PSIA (OFI)
1	1	Pressure 0-3000 PSIA
12	0	Pressure 0-10 PSIA (MSFC)
0	3	Accelerometer ±400g (MSFC)
5	9	Strain ± 2K uIN/IN (4 ON RH SIDE MSFC)
5	9	Strain -2K/+6K uIN/IN (4 ON RH SIDE MSFC)

DEVELOPMENT FLIGHT INSTRUMENTATION (DFI) RSRM 1-6 MEASUREMENT

QUANTITY LH	RH	MEASUREMENT
		FORWARD SEGMENT
9	9	Girth -2K/+6K uIN/IN
1	1	Temperature Sensors 0 to 400 F
9	9	Temperature Sensors ± 200 F (GEI)
		FORWARD MIDDLE SEGMENT
2	2	Accelerometer ±10g
10	10	Girth -2K/+6K uIN/IN
4	4	Strain ±2K/+6K uIN/IN
4	4	Strain -2K/+6K uIN/IN
3	3	Temperature Sensors 0 to 400 F
10	10	Temperature Sensors ± 200 F (GEI)
LH	RH	AFT MIDDLE SEGMENT
3	3	Accelerometer ±10g
10	10	Girth -2K/+6K uIn/IN
12	12	Strain ± 2K uIn/IN (4 EACH SIDE MSFC)
12	12	Strain -2K/+6K uIn/IN (4 EACH SIDE MSFC)
3	3	Temperature Sensors 0 to 400 F
6	6	Temperature Sensors ± 200 F (GEI)
		AFT SEGMENT
6	6	Accelerometer ±10g
11	11	Girth -2K/+6K uIn/IN
31	31	Strain ± 2K uIn/IN
31	31	Strain -2K/+6K uIn/IN
17	17	Temperature Sensors ± 200 F (GEI)
		NOZZLE & AFT DOME
4	4	Accelerometer ±10g
9	9	Girth -2K/+6K uIn/IN
15	15	Strain ± 2K uIn/IN
15	15	Strain -2K/+6K uIn/IN
4	4	Temperature Sensors 0 to 400 F
9	9	Temperature Sensors -50 to 750 F
12	12	Temperature Sensors ± 200 F (GEI)
1	1	Continuity

3. EXPERIMENTAL VERIFICATION OF ORBITER FLIGHT LOADS:

ASAP FINDINGS AND RECOMMENDATIONS: The Panel found that data from the pressure gauges installed on vehicle Orbiter 102 cannot be relied upon for predicting wing loads accurately, and therefore, data from the installed strain gauges will have to be used to verify the Automatic System for Kinematic Analysis (ASKA) 6.0 loads/stress analyses. The strain gauges installed on the vehicle have never been calibrated as installed.

The Panel recommends that Orbiter 102 undergo a loads test program to calibrate the strain gauges installed so that flight data from these gauges may be used with confidence to obtain wing loads in flight. This testing should be accomplished during present hiatus in STS flights. (p. 36)

NASA RESPONSE: Please refer to Chapter I, Section 2, p. I-11.

4. SPACE SHUTTLE MAIN ENGINE (SSME)

ASAP RECOMMENDATION: The changes described above primarily address hardware reliability, firmer redlines and configuration control and improved hardware cycle life. In only a few instances will there be any significant improvement in margin to failure. The Panel recommends, therefore, that the Phase II engine be constrained to operate at 104-percent rated thrust or less. Furthermore, it must be noted that a significant increase in operating margin of safety can be achieved by operating a 100-percent rated thrust. It would be prudent, therefore, to operate at 100-percent thrust until the Phase II engines have accumulated significant flight operating time so as to provide a meaningful data base.

The Panel recommends that the two-duct hot gas manifold and the large throat combustion chamber be tested and certified as soon as possible. It is the opinion of the Panel that these changes will produce lower stress environments and improve margins at 104-percent thrust levels.

It is also recommended that the NASA and its SSME contractor continue the development of improved methods for actually demonstrating critical operating failure mode margins and the more rigorous Risk Assessment analytical procedures. It is suggested that, as part of the procedure, the term "failure" be defined as a violation of any of the governing design criteria for a component rather than as an event such as structural failure or burn-through. By way of illustration, crack growth to the point where a calculated stress margin falls below 1.4X should be call "failure" rather than when it reaches the "rupture critical flaw size." (p. 48, 49)

NASA RESPONSE: The SSME power level will be limited to 104-percent maximum, except in emergency situations, when the program returns to flight status. An extensive ground test program, including margin demonstration test (higher power level, longer duration, off normal performance response, and combinations of the above) has been defined and is being performed to demonstrate "margin to failure" at 104-percent power level. Continued testing of improved turbopumps will lead to increased margins.

The two-duct hot gas manifold/large throat main combustion chamber (precursor engine) is assembled. The precursor test series to evaluate changes with significant margin gain potential in the hot gas flow environment will begin in the fourth quarter of CY 1987.

NASA is continuing development of improved methods for actually demonstrating critical operating failure mode margins and more rigorous risk assessment analytical procedures. For demonstration of critical operating failure mode margin an extensive ground test program, including margin demonstration tests (higher power level, longer duration, and off normal performance response) has been defined and is being performed. Our test procedures do not require that each and every violation of the design criteria be categorized as a "failure". However, each and every violation does require that an Unsatisfactory Condition Report (UCR) be written and tracked by the SR&QA organization. The UCR must document the discrepancy and can only be closed out with a failure analysis report that addresses cause and corrective action.

5. SHUTTLE COMPUTER SYSTEM

ASAP COMMENTS: Reliability of new and old General Purpose Computers (GPC) - It seems clear that on paper the new GPC is more reliable than the original, but it does not have the flight testing of the original. All of the problems found in the original GPC have been corrected in both the current versions of the original GPC and the new GPC. If an original GPC is used, it will be a processor that has been in use for several years, not a new production copy of the original design. This has potential for both positive and negative effects. Through its use any initial manufacturing defects have been eliminated. However, as it has been in use for several years, one must question the effects of aging. (p. 55)

NASA RESPONSE: For this new GPC, an Electronic, Electrical, Electromechanical (EEE) parts upgrade regimen imposed tighter process controls and inspections, aimed at correcting reliability problems experienced on the old GPC. However, the new GPC does have some areas that must be actively worked to ensure adequate reliability. For example, the contractor has proposed a high density memory with a radiation damage risk, and a digital microcircuit family for which the manufacturer is still evolving wafer processing techniques. Also, the inspection and process control requirements of the parts upgrade program have necessitated using less experienced microcircuit assembly houses that could be in a learning period during the GPC build. All of these issues are being actively worked by the GPC project and their resolution is a high priority. The ASAP report states that all of the original GPC problems have been corrected in current versions of the original GPC. It is probably more accurate to say that corrective actions have been taken to the extent possible to address parts problems such as particle contamination and electromigration. The actual correction occurred when the suspect parts were designed out in the new GPC. Finally, we feel that the GPC with the new Complimentary Metal Oxide Silicon (CMOS) memory and associated circuitry, does have the potential for substantially improved reliability when fully qualified.

ASAP TECHNICAL CONCERN: The methods of determining and validating the 8,000 I-LOADS that must be defined for each shuttle flight. These constants define the mission to be flown and are as important as the software and computers to the success of a mission. (p. 58)

NASA RESPONSE: This technical concern was intended to indicate one of the topics that ASAP would like to have detailed reviews on at JSC during the coming year. The organization which is to be contacted to set up this review is Mr. Jack Boykin, Code WG, Telephone: 525-6136. (This response has been coordinated with the ASAP Staff Director, Gilbert L. Roth).

ASAP TECHNICAL CONCERN: Implications of proposed flight schedules on flight software testing on the Shuttle Avionics Integration Laboratory (SAIL) facility. In particular, there are concerns that the increased flight schedules will force reduced per flight testing.

NASA RESPONSE: This technical concern was intended to indicate one of the topics that ASAP would like to have detailed reviews on at JSC during the coming year. The organization which is to be contacted to set up this review is Mr. Jack Boykin (software), Code WG, Telephone: 525-6136; and Mr. Frank Littleton (hardware), Code VG, Telephone: 525-2744. (This response has been coordinated with the ASAP Staff Director, Gilbert L. Roth).

ASAP TECHNICAL CONCERN: The methods by which software tests are generated. The quality of the resulting software is highly dependent upon these procedures. (p. 58)

NASA RESPONSE: This technical concern was intended to indicate one of the topics that ASAP would like to have detailed reviews on at JSC during the coming year. The organization which is to be contacted to set up this review is Mr. Jack Boykin, Code WG, Telephone: 525-6136; and Mr. Frank Littleton, Code VG, Telephone: 525-2744. (This response has been coordinated with the ASAP Staff Director, Gilbert L. Roth).

ASAP TECHNICAL CONCERN: The methods by which compiler upgrades are tested. The compilers translate the program written for the Shuttle into the code execute by the computers. (p. 58)

NASA RESPONSE: This technical concern was intended to indicate one of the topics that ASAP would like to have detailed reviews on at JSC during the coming year. The organization which is to be contacted to set up this review is Mr. Jack Boykin, Code WG, Telephone: 525-6136. (This response has been coordinated with the ASAP Staff Director, Gilbert L. Roth).

ASAP TECHNICAL CONCERN: More detail on the redundancy management among the computers, in particular, timing and comparison methods. (p. 58)

NASA RESPONSE: This technical concern was intended to indicate one of the topics that ASAP would like to have detailed reviews on at JSC during the coming year. The organization which is to be contacted to set up this review is Mr. Frank Littleton, Code VG, Telephone: 525-2744. (This response has been coordinated with the ASAP Staff Director, Gilbert L. Roth).

ASAP TECHNICAL CONCERN: General hardware and software support system upgrade policies. It is not clear that NASA has general procedures. In the aftermath of the GPC upgrade, it would be a good idea to examine this issue and encourage NASA to develop suitable procedures. (p. 58)

NASA RESPONSE: This technical concern was intended to indicate one of the topics that ASAP would like to have detailed reviews on at JSC during the coming year. The organization which is to be contacted to set up this review is Mr. Jack Boykin (software), Code WG, Telephone: 525-6136; and Mr. Frank Littleton (hardware), Code VG, Telephone: 525-2744. (This response has been coordinated with the ASAP Staff Director, Gilbert L. Roth).

ASAP PERSONNEL CONCERN: Much of the knowledge of shuttle computer development and operation resides in the corporate memories of the employees who have worked on the system. The age distribution of the employees working on the computer system is of concern. There have been initial inputs that the current staff is heavily skewed toward the older age groups and that there is a dearth of employees in the mid-age group. (p. 59)

NASA RESPONSE: The NSTS organization shares ASAP's concern about aging corporate knowledge of shuttle computer development and operation. An intensive effort is being made to hire and train new college graduates.

ASAP PERSONNEL CONCERN: Some concern has been expressed about pressure from above to state that adequate tests can be performed within budget, whether or not they can be: it is also implied that if individuals do not conform, someone else will be found who will. (p. 59)

NASA RESPONSE: Adequate tests will be run on the GPC hardware and corresponding software. There are a number of organizations at JSC involved in the verification of these items including a Level II Change Control Board and software advocates whose sole job is to ensure proper tests are conducted. The budget will be made to accommodate the required testing.

There will be no improper pressure on individuals to conform. There are clear channels of communication both within the program structure and independently through the SRM&QA organization to ensure that any potential problems of this nature are surfaced and properly addressed. Further, the recently announced NASA Safety Reporting System provides a mechanism for any individual who encounters this type of problem to bring it to the attention of the highest levels of NASA management, with a guarantee of anonymity.

6. ORBITER LANDING GEAR SYSTEM:

ASAP COMMENT: Prior to first reflight, a heavyweight brake dynamometer facility will be assembled and used to verify braking capability. (p. 61)

NASA RESPONSE: The interim thick stator beryllium brakes planned for use on the first reflight have been tested at the Goodrich dynamometer facility. Although not a requirement to verify the interim thick stator brakes at the WPAFB dynamometer facility prior to first reflight, consideration is being given to testing the thick stator at this facility. It is planned to test the new structural carbon brakes at the WPAFB dynamometer facility. The WPAFB dynamometer will be modified to incorporate a full up landing gear assembly for the brake tests.

ASAP COMMENT: Additional areas are being investigated as part of the effort to improve the orbiter braking system. These areas have not, however, been designated as mandatory for first reflight. They include items such as use of an orbiter drag chute, upgrading of nose-wheel steering system, and wheel spin-up devices. Also, landing and roll-out simulations are to be conducted at the Ames Research Center (ARC) flight simulators. The Panel will continue to monitor progress in these areas. (p. 62)

NASA RESPONSE: Potential modifications under study and test include roll on rim, gear skids, tire tread material change, FO/FS nose-wheel steering and the drag chute. These modifications will be presented to the System Design Review Board for decision as to implementation.

The ARC landing and rollout simulations were conducted during the February-March 1987 time period. Over 1,100 runs were made with 15 pilots participating. All simulation objectives were accomplished with results including:

- Nose-wheel steering performance with the updated tire model closely matched last year's performance.
- The anti-skid function released the brake pressure on the two remaining wheels after the two tires were blown. Large braking recovery times (up to 6 seconds) resulted. The contractor is evaluating the system performance in this area and a change request is being considered to reduce the recovery time.
- The simulated drag chute demonstrated significant improvements in stopping distance, brake energies, and main tire load.
- Simulation data is being processed to statistically characterize tire wear versus crosswind.

IV. SPACE SHUTTLE OPERATIONS

1. LAUNCH PROCESSING

ASAP COMMENT: The issue of weather forecasting has been under review for some time as it affects operations at KSC. The need for more accurate and timely weather data, particularly winds aloft and rain, has been apparent and became more apparent as the pace of operations increased. (p. 65)

NASA RESPONSE: In 1984 a Meteorological System Modernization Program (MSMP) was initiated and a joint KSC-AF working group was created to assess the center's operational weather requirements. Over time this group has been broadened to address the full scope of both manned and unmanned weather requirements, with representatives from HQ, MSFC, and JSC.

A major advancement in forecasting capability was realized when NASA procured and installed a Meteorological Interactive Data Display System (MIDDS) at the Cape Canaveral Air Force Station (CCAFS) in 1985. MIDDS provides forecasters with a tool to integrate a multitude of data products (satellite data, winds data, radar imagery, etc.) into a concise format allowing more time to visually analyze dynamic weather systems impact on space operations.

In response to the Shuttle Weather Advisory Panel reports, NASA is implementing a five-year Weather Forecasting Improvement Plan. A cornerstone of the Plan is a study by the National Research Council, beginning in July 1987, to assess the feasibility of instrumenting KSC as a prototype nowcasting facility to ensure that state-of-the-science technology and forecasting methodology are utilized to support the space program. Another noteworthy element of the plan includes the installation of a radar wind profiler in 1987 that will aid in the assessment of winds aloft affecting manned and unmanned launches. In recognition of KSC's unique operational weather requirements, the AF has provided NASA with a weather officer dedicated to support the center's day-to-day needs. In light of the recent Atlas Centaur accident, we are further calculating our lightning requirements and prediction capability.

ASAP COMMENTS: There is a substantial amount of unplanned and previously deferred work at KSC. This is particularly true for the orbiters. This work must be carefully scheduled and accomplished. (p. 66)

NASA RESPONSE: The NASA NSTS management and development contractors have conducted thorough reviews of all previously deferred open work on all flight hardware, GSE, and facilities at KSC for reclassification, replanning, and rescheduling purposes. This was related to the FMEA/CIL, safety, processing requirements and procedures (OMRS/OMI) reviews. The open work, including orbiter and GSE modifications, has been classified as to criticality (for safety), which modifications are mandatory for return to flight status (RTFS), which are required before flight of each element and which modifications can be delayed for how long or for windows of opportunity. These classifications are now being utilized to carefully schedule those modifications required before RTFS, those before each orbiter's first flight, etc. The schedules are being planned to provide adequate time for the available workforce to accomplish the required modifications before the related target launch dates. Of course, modifications which can be further deferred will wait for windows of opportunities for installation between missions as required.

ASAP COMMENTS: Workers often expressed the opinion that training should employ real or equivalent hardware and situations so that the trainee can attain proper understanding of the hardware, software, and procedures. It was also suggested that competent supervisors and/or engineers should give the technical training courses rather than a training staff considered to be unfamiliar with the "real world." (p. 66, 67)

NASA RESPONSE: NASA KSC, the element contractor and SPC management have enhanced the formal courses and on-the-job training with increased simulation. KSC is currently conducting monthly T-20 minute countdown simulations. Included in the current budget request is a launch team training simulation plan (LTTS). This system consists of a firing room simulator (hardware and software) of the shuttle on-board flight system and associated ground support equipment. It will be used for training engineers and support personnel in subsystems operations and integrated shuttle processing scenarios. This integrated training system will better simulate the launch environment and reduce the overall time to train.

All plans for training activities are strictly reviewed by management. Additionally, shop supervisors and systems engineers will be involved not only in instruction, but also in the preparation of course material.

ASAP COMMENTS: The "hands-on" personnel exhibited respect for and reported satisfactory relations with most engineers. There was, however, concern expressed about the lack of experience and/or ability of many of the newly hired engineers. (p. 67)

NASA RESPONSE: There exists an excellent rapport between the engineers and floor workers, achieved primarily through "liaison engineering" personnel who work directly on-the-floor with the operations technicians and quality personnel in response to questions, problems and issues arising during processing. As the workforce is being expanded, "newly hired engineers" are being incorporated through training activities, familiarization roles with the liaison engineers, and practical experience during the RTFS mod and reactivation phase. The SPC and NASA managers feel that this methodical approach is the best way to bring in additional new engineers, determine their capabilities and allow them to develop their familiarity, confidence, and respect of the workers who will eventually implement their plans (instructions).

2. LOGISTICS

ASAP RECOMMENDATION: Establish control of the pipeline for the repair of Line Replaceable Units (LRUs), in particular, as well as for other components. This will probably include the need for a repair depot on-site at KSC. Although it will still be necessary to return certain sensitive units to the manufacturer for repair, the number of such units should be kept to a minimum. (pg. 68)

NASA RESPONSE: KSC shuttle logistics has established controls for the repair of LRUs. These controls include establishing a KSC Logistics Control Board to control repair actions; locating the orbiter logistics contractor next to NASA Logistics in the new KSC Logistics Facility for better communication and working relations, holding weekly scheduled interface meetings between RI, LSOC, and NASA logistics to review and resolve problem areas; and interfacing with RI/Downey management at monthly progress meetings to review all actions concerning orbiter logistics.

In addition, closer working relationships are being established with the new KSC SR&QA Directorate to make it an integral part of the repair process. This should resolve many areas of concern that are caused by communication and documentation problems.

ASAP RECOMMENDATION: Determine, as soon as feasible, the impact of the "maintenance safeguards" program. If there is a financial effect (i.e., increased spares requirements) necessary, budget modifications should be made promptly. (p. 68)

NASA RESPONSE: The program requirements for "maintenance safeguards" was approved as the System Integrity Assurance Program Plan on March 30, 1987. This includes maintenance and logistics requirements. For example, it requires a 90 percent probability of sufficiency for direct support spares. Each NSTS project is currently preparing implementation plans and impact assessments for these requirements. These implementations will be reviewed and approved by the Program Requirements Control Board (PRCB) and will include approval for additional resource allocations.

ASAP RECOMMENDATION: Ascertain the effect of the planned maintenance program on logistics. Make necessary adjustments to spares required. If the maintenance program planning is not yet complete, do so promptly in order that the effect on spares requirements may be known and incorporated into the recovery plan. (p. 68)

NASA RESPONSE: Current maintenance experience and planning have been reviewed as a routine management activity within KSC shuttle logistics activities. Actual experience, as well as projected impacts, are factored into spares quantification determinations to assure availability at the point of need. Real time unanticipated impacts are considered/evaluated for most rapid recovery possible within physical and/or monetary limits.

Spare parts have been ordered to support the implementation of the maintenance/structural inspection program. KSC Logistics, Flight and Ground Project Division is working with systems engineering to establish the schedule, areas of the orbiter to be inspected, and ordering items that will be replaced or have the potential of being replaced.

ASAP RECOMMENDATION: Determine the effects, if any, of the results of the ongoing shuttle design review program (if any) and factor them into logistics planning. (p. 68)

NASA RESPONSE: Logistics impacts and required actions are identified as a part of modification/design review procedures. The logistics program has been represented on the shuttle design review and implementation teams. Also, organizations/personnel have been established to monitor and participate in the completion of required activities. For example, the orbiter brakes are being redesigned which will also result in a redesign of the inner wheel halves. This action has initiated meetings/telecons between JSC and KSC to determine the proper quantity of wheel halves and new wheels to support flight processing, roll around and contingency landing site operations. KSC systems engineers are preparing several operational scenarios, which may result in various quantities of wheels to be procured.

ASAP RECOMMENDATION: Re-examine and assess the logistics targets to ensure that they are compatible with realistic flight rates. (p. 68, 69)

NASA RESPONSE: Since the Logistics responsibility transfer from JSC to KSC, there have been several grass roots exercises done in terms of logistics targets, both technical and budget, to ensure compatibility with the current flight manifest. Immediately after the transition from JSC to KSC in July 1986, and in preparation for the Program Operating Plan (POP) 86-2 budget cycle, KSC performed a bottoms-up assessment of the logistics program. A complete hardware supportability assessment was performed and all hardware required to support the fight rate is on order. Repair and depot requirements were all assessed and sufficient dollars are in the budget to support the technical requirements.

ASAP RECOMMENDATION: Establish a program to determine which components, devices, or parts are no longer available or may become so as a consequence of the supplier going out of business or ceasing their manufacture. Establish an activity to obtain equivalent hardware. (p. 69)

NASA RESPONSE: Requirements have been established within logistics support contractor activities to ensure future sensitivity to aging hardware systems, vendor discontinuance, and/or cessation. Projection of need and prior determination of replacement hardware is an objective which has met with limited success due to unexpected changes in business climates. In some instances, life of the program spares have been procured when prior notice of unavailability can be determined. In other instances, expensive real time redesign and replacement have been necessary. For example, Harris Corporation has made a "life of program" buy of certain solid state devices to be retained for repair parts. This should eliminate costly redesign/requalification of suppliers.

ASAP RECOMMENDATION: Reduce pipeline turnaround times for all critical LRUs. (p. 69)

NASA RESPONSE: Actions underway to improve turnaround time at the OEMs include:

- Streamline repair authorization procedures
- Improved repair scheduling and tracking system being installed
- Repair deferral eliminated
- Proper staffing of essential skills
- Consolidation of repair activities at the RSC
- Improved repair parts lay-in
    - OEMs are being tasked to recommend and procure required parts
    - Rockwell has established a new economic order policy that allows more flexibility for the OEMs.

These actions should help to achieve the desired turnaround times. Use of the RSC Depot will also increase KSC's direct control over repair actions.

3. SHUTTLE FLIGHT SIMULATORS

ASAP RECOMMENDATION: The shuttle flight simulator program requires an additional airplane because the current three airplanes are aging and will soon require major modification. The restart this year of the astronaut mission related training program will require the fourth aircraft in order to maintain the proposed flight schedule. Although this is approved, it appears to be suffering from lack of top management attention.

NASA RESPONSE: NASA has $21.2M in the budget for the 4th Shuttle Training Aircraft (STA). The STA will be ready for training in June 1990. We are investigating two options for the purchase of the aircraft. The first option is to purchase the Lewis Research Center Propfan Test Assessment (PTA) Gulfstream II aircraft. The other option is to purchase the Gulfstream II aircraft on the open market. The cost of the PTA aircraft is approximately $2M lower than an aircraft on the open market. However, there is a question of whether the PTA aircraft will be suitable because of potential structural problems caused by the PTA program. We intend to procure the PTA, but if found to be unacceptable, we will make an open market purchase.

ASAP RECOMMENDATION: NASA Headquarters should ensure that this program is continued and completed in a timely fashion so that astronaut training will not be delayed or restricted. (p. 69)

NASA RESPONSE: NASA Headquarters will continue its program responsibility through funding and direction to assure that the required training is accomplished prior to each shuttle mission. The current funding for the procurement of the 4th STA will enable its delivery in June 1990. Prior to that date, the present fleet of aircraft will provide the necessary training requirements to meet the current scheduled space shuttle manifest.

V. SAFETY, RELIABILITY AND QUALITY ASSURANCE

ASAP OBSERVATION: The objective of a System Safety Program in any enterprise or organization should be to manage such risk to an acceptable level (not zero) throughout the operational life cycle of the system. We believe there are also issues with the basic methodology used to ensure that risks are adequately projected (quantitatively) and then controlled to the levels accepted. (p. 72 and 73)

NASA RESPONSE: The Agency has a major effort underway to improve our risk management and risk assessment programs. Several current case studies are to evaluate the applicability of probabilistic analysis to improve understanding of failure modes. Improvements to trend analysis capabilities have also been initiated.

Systems assurance policies that will establish more uniform criteria for risk assessment are also in development. Risk assessment models that will evaluate in terms of undesired scenarios and their severity, and likelihood, will be required. Management structures and procedures will be revised to include a thorough review of the results of these new risk assessment models at the various decision points. Systems assurance requirements for Project Managers, implementation guides, and a specific Systems Assurance Program Plan for the STS are in draft form and will be available for use in the near future.

ASAP RECOMMENDATIONS: The Associate Administrator for SRM&QA should have full responsibility to establish a total system safety engineering program throughout NASA and be given the authority to assure its full implementation. A system safety engineering organization reporting to the Associate Administrator should generate the overall safety program policies to be followed. It would also define the critical design criteria to be used and the testing program methodology necessary to assure that those criteria have been properly validated. This Headquarters organization would also establish requirements and methods for performing overall system integration hazards analysis and for the generation of quantitative risk assessments tied to controllability of failure mode margins and test and flight results. (p. 73)

NASA RESPONSE: The Associate Administrator for SRM&QA (Q), chartered an Ad Hoc committee called "The STS Safety Risk Assessment Ad Hoc Committee" to review the STS flight centers (JSC, KSC, and MSFC), the STS element contractors, and the major payload centers (GSFC and JPL) and payload contractors in regard to their implementation of the STS safety process. These reviews and discussions indicated inconsistencies in the management approaches at various levels and some confusion whenever system or organizational interfaces were addressed. The committee concluded that these problems were the result of a weak Headquarters safety function and a weak STS safety integration process. As a result of this report and other observations made by the Associate Administrator for SRM&QA, further staffing increases are planned and a reorganization of the system safety activities within SRM&QA is underway. The system safety engineering doing function will still reside in the program at various levels, and the policy and oversight functions will reside in the Headquarters SRM&QA organization and the center SRM&QA Director's organization, which reports to the center director, and by dotted line to the Headquarters SRM&QA organization. These activities are being strengthened by staffing increases and establishing the function at the proper level in the respective organizations. The Associate Administrator for SRM&QA will have the ability to assure proper center support through his involvement during the center budget requirements review. He will assure proper support in the STS program through his policy development and oversight role. Within Code Q, the system safety functions are being brought together under one manager and continue to be under the Safety Division. The function will consolidate Code Q system safety engineering policy and oversight responsibilities in the design and operations areas. Critical safety design criteria and test methodology to assure those criteria have been properly validated will be developed within the System Safety Branch. Several new system safety policy and requirement documents are being developed, including procedures for performing specific hazard analyses and risk management assessment. As we envision it, a system safety training program is a necessary and vital ingredient to assure the program and project managers understand the role, interface, and responsibility of system safety in the decision-making process. An audit plan will be developed, to periodically review the NASA and contractor organizations at all levels. The requirements and methods for performing overall system risk assessment are currently being defined. The quantitative methods applicable to the generation and communication of risk assessment information are being reassessed.

ASAP RECOMMENDATION: Reliability, configuration maintainability, and operations safety engineering should be integral parts of this system safety engineering organization and it would provide policy direction for these functions throughout NASA. The definitions of policies and operating instructions for the quality assurance functions which are a vital part of risk management should also be the responsibility of the Associate Administrator. The policies and implementation directives should be implemented by system safety organizations reporting to the director's office at each NASA center. As appropriate, personnel from these organizations could be matrixed into the various programs. A significant part of NASA funds to be spent in safety areas should be allocated directly to the system safety organizations. This would provide assurance that necessary safety engineering activities can be controlled independently of the funding tradeoff pressures which always exist within programs. (p. 78)

NASA RESPONSE: We do not agree with the suggested amalgamation of various additional disciplines under the system safety organization. System safety over the years has developed into a well-defined technical discipline. We recognize that the application of existing system safety principles within NASA needs improving, and we are actively expanding the caliber and quantity of personnel, both within NASA and our contractors. To broaden the scope of this activity at this time, we believe, would be counter-productive. In the case of operational safety, we have chosen to deliberately highlight it as a separate organizational entity to provide added focus on an element that we recognize as needing significant added emphasis. We plan to continue to treat these as separate functions but strengthen the interaction and coordination between these groups. We agree that the quality assurance functions are a vital part of the overall risk management and these are, in fact, the responsibility of the Associate Administrator for SRM&QA. We believe they can be managed more effectively in a separate organization and we plan to continue to keep quality assurance in the RM&QA Division. At the local level, implementation of system safety policies and directives will be accomplished by the program or project line organizations with review by the center system safety organization which reports to the center director through the Director of SRM&QA at the center. We do plan to matrix the center system safety personnel into the various programs and will do this in a much more disciplined manner so that we can still maintain oversight and review objectivity in the center organizations.

The funding support issue we believe can be handled by the Associate Administrator for SRM&QA's involvement in the center's budget review process, for center support and by his oversight role for programs and projects. We believe we can protect the safety engineering activities from the tradeoff pressures which we agree do exist in the normal course of program operation without a direct funds allocation for the Associate Administrator for SRM&QA.

ASAP FINDING: The Panel recommends that NASA should emphasize development of Non-destructive Evaluation (NDE) techniques for assistance in qualifying critical STS elements. (p. 80)

NASA RESPONSE: NASA recognized the need for special attention in NDE and has had annual NDE meetings with NASA and contractor participation. The November 1986 meeting was directed toward SRM NDE. Also, a more indepth SRM NDE meeting was held at MTI in January 1987 with NASA HQS, LaRC and MSFC participants. One major accomplishment was achieved with the development of an ultrasonic technique to explore propellant to liner debond from outside the SRM steel case. Other NDE techniques are being investigated to inspect areas in the SRM where standard NDE methods are not applicable. NASA has a commitment to expand the NDE program under the Associate Administrator for SRM&QA.

VI. SPACE STATION PROGRAM

1. BACKGROUND

2. MANAGEMENT

ASAP RECOMMENDATION: Reorganizational concepts emphasize that overall program guidance will be centered at NASA Headquarters, Washington, DC, under the space station office directed by the Associate Administrator for the Space Station. Day-to-day direction and control of the program will be conducted by the Program Director who heads the Space Station Program Office (SSPO) located in Washington, DC. Detailed performance of the development activities are assigned to NASA field centers. (p. 83)

NASA RESPONSE: The information on assignment of responsibilities listed in this section of ASAP is not fully accurate. The current status is as follows:

The program office, which is part of the NASA Headquarters organization, has the responsibility to define and provide the station-level requirements, functional partitioning and resource allocations to the systems and elements. It also has the responsibility to perform overall systems engineering and integration, including interface analysis and control between elements and end-to-end systems.

For design and development, space station elements and end-to-end systems architecture have been assigned to four "work packages" as follows:

Work Package	Element	End-to-End System
WP-01 (MSFC)	Hab Module Lab Module Log. Module(s) Logistics elements	ECLSS
WP-02 (JSC)	Truss MSS Mobile Base Propulsion Resource Nodes Airlock(s)	Data Management Thermal Control Comm & Tracking Guidance, Nav. & Control Man Systems Assembly & Maintenance
WP-03 (GSFC)	Platform(s) Servicing Facility Attached Payload Accommodations	Servicing
WP-04 (LeRC)	Power Modules	Power Management & Distr.

3. TECHNICAL AND RESOURCE RISKS

ASAP OBSERVATION: From the point of view of space station safety, there are three general categories of space station threats: hardware/software, human performance, and logistics/resupply. In brief it would appear that these are some of the risks:

- Human performance errors should be a major concern of space station design and operation.
- The docking, electrical, flight control, and instrument systems have great potential for adversely affecting space station operations.
- A major logistics/resupply threat is the unreliability of launch vehicles.

The baseline space station program associated with the "build-to-cost" concept is a resource risk.

NASA RESPONSE: The mention of resource risk in connection with "build-to-cost" concept is fairly obvious, and is common with all NASA programs for which we offer a cost estimate early in the life of the program. Other risks listed are associated with other uncertainties in this development program; they make a good starting list of relevant uncertainties. In fact, many of these concerns were addressed in the thoroughgoing cost-commitment review that preceded the program approval for the revised baseline program.

Additional review by the special committee of the National Research Council is currently underway. At the beginning of September 1987, we should have their comments and will be able to respond appropriately.

The entire reconstituted SRM&QA program has as its main objective to identify these types of risks as early as possible and work to eliminate them.

4. SPACE STATION COMPUTER SYSTEMS

ASAP RECOMMENDATION: The space station designs developed over the next 18 months will impact the station's utilization and safety for probably two decades. It is thus particularly important to ensure that the utmost care and planning go into the design. It is, therefore, appropriate for the Panel to investigate the planning. This preliminary report is, therefore, more a statement of principles than a detailed set of findings. The examination of this subject will continue during 1987. (p. 85)

NASA RESPONSE: It has been a primary objective of the space station program to implement the designs of the station systems in a form that is responsive to, or at least consistent with, both the current and foreseeable missions of the station. This approach manifests itself in designs and technology selections which will be modular, adaptable, and changeable without major impacts on users of the station. The approach pervades the entire conceptual design, from computers, ISA, and bus structures, to networks, communications media, and beyond. It is also a primary objective to use, to the maximum extent possible, proven off-the-shelf technology and standardized components and approaches.

The selection of the computer architecture will significantly affect the performance of the on-board systems, in both the IOC and growth phases of the station. In creating the architecture control documents, the Station Program has set performance requirements for the flight systems adequate to meet or exceed current and foreseeable mission requirements. The selection of the specific processor to be incorporated will be made not now, but after Phase C/D contractor selection at the time of the preliminary design review (PDR). The flight qualification status of the systems at that time will weigh heavily in the decision.

If a candidate architecture cannot reasonably be flight qualified in time to be incorporated into the flight systems, its putative benefits are put into serious question and it cannot be used without waiving the standards of good flight system engineering. Other considerations include performance, size, weight, cost, and second-source availability. All things considered, we intend to select the best overall machine. With LAN technology as the communications backbone, the modular systems architecture designs will permit the upgrade of the on-board computational capability as candidate technology matures through the phase of flight qualification.

No specific selection of the computer architecture, ISA, networking protocols, LAN type, or other hardware has yet been made, nor should it be made until the completion of the PDR activity, which is at least a year and a half in the future. As the Panel notes, there may be significant advances in available technology in that time, and we intend to capture the best overall combination in reach at the time of decision, while preserving the avenues for future upgrade.

We believe these same comments apply to the Panel's findings and recommendations on automation and robotics in the space station. (p. 88)

5. LIFE SCIENCES

ASAP RECOMMENDATION: Life sciences probably needs to establish a more effective mechanism within NASA so that it can compete for available funds.

NASA RESPONSE: The space station program agrees with the Panel statement about life sciences activities in NASA. In addition, we note the Panel's concern on page 84 about incorporating consideration of human performance errors in station design. It would appear that not only must the agency be concerned with fundamental physiological well being in the station era and on into the era of planetary visits, it must also be concerned with psychological and psychiatric well being that can determine whether humans aboard the station will be able to function safely and efficiently.

B. THE ROTOR SYSTEMS RESEARCH AIRCRAFT/X-WING FLIGHT TEST PROGRAM (RSRA/X-WING)

ASAP COMMENT: Of primary concern is the raising of the vertical center-of-gravity of the vehicle by some 18 inches as compared with the standard RSRA vehicle. (p. 92)

NASA RESPONSE: The contractor/government team mutually agreed that a prudent approach to flight testing was to increase gross weight and vertical c.g. incrementally using five different configurations. The first three of these configurations are without the rotor and they were briefed and accepted by the Flight Readiness Review Board at the June Flight Readiness Review.

1. FLIGHT READINESS REVIEW

ASAP RECOMMENDATION: The Flight Readiness Review Board (FRRB) is structured in a way that will assure complete and adequate coverage of the X-Wing design activity. Included should be an evaluation and assessment of all data from the various X-Wing test and simulation activities. (p. 93)

NASA RESPONSE: These topics were addressed in the June Review and will be addressed at the Flight Readiness Reviews for each phase of flight testing.

ASAP COMMENT: Adequate correlation of dynamic analysis with the stopped rotor wind tunnels tests is not clear. Also, the plan for showing a wind tunnel/analytic correlation should be improved. (p. 94)

NASA RESPONSE: Flight test data from N740NA has now been correlated with the rotorless configuration at nominal gross weight. A global computer model is now available using both GENHEL (handling qualities) and REXOR (dynamics) for stopped rotor configurations. This modeling is continually updated to incorporate wind tunnel results.

ASAP COMMENT: The structural divergence prediction from the tunnel tests were not conclusive — some differences in the data are not accounted for. (p. 94)

NASA RESPONSE: There were no indications of structural divergence within the planned flight test envelope resulting from the wind tunnel tests. Performance measurements and hub moment measurements without putting grit on the blade surfaces to fix the location of boundary layer transition, did not correlate with the analytical predictions. Satisfactory correlation has been obtained using grit on the blades and making appropriate Reynold's number corrections. It should be noted that these data are not relevant for rotor-off flight testing.

ASAP COMMENT: The flutter and divergence analyses results performed by Northrop need further refinement. It is difficult to address the meaning of the results of the flutter analysis. (p. 94)

NASA RESPONSE: These analyses are continually being refined and now include flexible blades and better dynamic modeling. Neither structural divergence or flutter are predicted to occur within the RSRA/X-Wing flight envelope.

ASAP COMMENT: Various aerodynamic models for downwash interference are being used. Results from powered model tests are not in agreement with predicted analytical model results. (p. 94)

NASA RESPONSE: As previously stated, these initial models were rough predictions and good correlation was not expected. Current modeling is consistent with the measured downwash from the wind tunnel tests.

ASAP COMMENT: Current Northrop controls/dynamic analysis is conducted for 200 kts/2.5 degree angle of attack. The analytic method may not cover 140 kts to 250 kts of the flight envelope. (p. 94)

NASA RESPONSE: The methodology is believed to be valid for the complete stopped rotor envelope, and comprehensive results will be briefed for the proposed envelope for each phase of flight testing.

ASAP COMMENT: Better definition of the telemetering requirements with emphasis on software requirements for automatic monitoring is needed. (p. 94)

NASA RESPONSE: The project office agrees that better definition of the telemetry requirements is needed and we are presently reviewing "do not exceed limits" in order to establish go/no go requirements. As previously stated, there is no requirement for automatic monitoring. Past experience has shown that such monitoring is not desirable when a large number of parameters are involved.

ASAP RECOMMENDATION: There is a need for a well thought-out written plan that describes the expansion of the flight envelope in a methodical manner to ensure avoidance of flutter divergence and tail buffet. The flight data should be correlated with the analytical and wind tunnel test data at each point as the envelope expansion proceeds. (p. 95)

NASA RESPONSE: A written flight test plan is now available for review which covers the rotorless phase of flight testing. It is intended that all math modeling will be continually updated as flight test data become available.

2. PROPULSION SYSTEM TEST BED (PSTB) AND OTHER SIMULATION

ASAP RECOMMENDATION: As a result of drive train problems encountered on the Propulsion System Test Bed (PSTB), additional running time should be allocated to the PSTB. (p. 96)

NASA RESPONSE: The 50-hour drive train endurance run was increased to a 75-hour run that has now been successfully completed. A transmission teardown inspection was performed after the endurance run with no significant anomalies being observed.

4. X-WING SAFETY

ASAP RECOMMENDATION: The Panel recommends that NASA should complete a fault and failure analysis to provide an adequate level of confidence for its use. (p. 97)

NASA RESPONSE: The contractor has provided a comprehensive Failure Mode Effects Criticality Analysis (FMECA) and hazard analysis that has been reviewed by the Project Office. An Operating Hazard Analysis that is being jointly prepared by the contractor and the government will be completed prior to first flight of the aircraft.

D. NATIONAL AERO-SPACE PLANE (NASP) SAFETY CONSIDERATIONS

ASAP COMMENT: A major technical issue is the establishment of an adequate data base and overall validation of the design of the experimental manned transatmospheric research vehicle since the full-scale vehicle cannot be ground tested through the full range of operational flight speeds, Mach numbers, and altitudes. A thorough evaluation of existing ground research facilities, their modernization and upgrading needs, the need for new ground facilities, as well as possible flight research facility options must be established and the corresponding budget requirements defined. (p. 101)

NASA RESPONSE: NASA is in complete agreement with the ASAP recommendations. Phase 2 is specifically directed to the development of the design data base prior to and in support of the decision to proceed to the Phase 3, X-30 design, construction, and flight test. A review of facility capabilities and CoF requirements has been underway since program inception and will continue through Phase 3. This activity supports both NASA's CoF and DOD Milcon planning and out year activity. In addition, at the direction of the NASP Joint Project Office at Wright-Patterson Air Force Base, a panel of flight test specialists from the Air Force Flight Test Center and Ames/Dryden has been established to plan and coordinate development of the X-30 flight testing program.

VIII. STATUS OF "OPEN" ITEMS FROM JANUARY 1985 REPORT AS REPORTED IN JANUARY 1986 REPORT

ASAP ITEM: Space Transportation System Operations Contract (STSOC) at JSC goes into effect January 1, 1986. Panel is requested to follow this as they did the SPC at KSC. (p. 116)

NASA STATUS: The purpose of the STSOC contract was to consolidate numerous support contractors that supported the operation of the space shuttle fleet. At the time of the Challenger accident, Rockwell Shuttle Operations Company (RSOC) was involved in the transition portion of the contract. Due to the expected reduction in operational support, NASA directed RSOC to reduce transition hiring, use RSOC sustaining engineering capability to reduce backlog of facility modifications and discrepancies, and modify training of RSOC personnel by incumbents. After the transition period ended in June 1986, RSOC was tasked to actively participate in the 51-L recovery process to provide support for facilities maintenance, maintain proficiency for flight support, and establish management procedures for reliability and control. Due to major differences in the original Statement of Work (SOW) and current operating requirements, renegotiations are currently underway for the remaining portion of the option period of the contract.

ASAP ITEM: Review the launch constraints being modified in order to increase launch probability and turnaround mods, as well. (p. 116) - Open

NASA STATUS: NASA is reviewing the entire launch commit process, including launch constraints, to ensure safety, efficiency, and clarity. Launch constraints will be as flexible as possible, consistent with a safe operation. Turnaround mods will be reviewed for completeness, understanding, and necessity so that a rapid, safe turnaround of the shuttle may be accomplished.

ASAP ITEM: Comprehensive maintenance plan supposed to have been released September 1985. (p. 116)

NASA STATUS: The "Maintenance Safeguard" plan was not released in September 1985 as planned, but rather the System Integrity Assurance Program Plan (SIAPP) was released in March 1987. Development of the comprehensive maintenance requirements which could be applied to program elements required more time than originally anticipated. The program did proceed with elements of this program prior to the formal release of the SIAPP. The requirement for design center review and approval of launch center procedures was implemented prior to SIAPP approval. Program Compliance Assurance Status System requirements were developed in parallel with the SIAPP development to assure that essential program requirements would be implemented prior to the next flight.

ASAP ITEM: Initial lay-in of spares to be completed by October 1987. Status, impact of reduced funding... particularly if it affects safety. (p. 116)

NASA STATUS: Lay-in of initial spares is to be completed by April 1989. The delivery of rate spares is to be completed by September 1991. A rebaselining of the logistics program occurred in October 1985, and March 1986, which resulted in a completion date of April 1989, for initial lay-in of spares, and September of 1991 for rate spares. Current performance is on target to achieve this plan. All lay-in and rate hardware is on order to support these milestones.

ASAP ITEM: SSME precursor test program to be completed during CY 1985. (p. 116)

NASA STATUS: The precursor engine 0208 is assembled and is scheduled for the first test series to begin October 1987. The precursor program is delayed due to funding and test stand availability.

ASAP ITEM: Results of Rockwell's detailed fracture/fatigue analyses for test article LI-36 (wing/mid-fuselage/aft-fuselage) structure being conducted June 1985 to January 1986. (p. 116)

NASA STATUS: The fracture/fatigue analysis for LI-36 continues to be deferred to FY 1988 due to budget constraints. The primary work to be completed here is to verify the capability of the subject structure to meet its design life of 100 missions times a factor of 4. In view of the limited number of flights to be accumulated on each orbiter by FY 1988, completion of the LI-36 analysis is not considered to be mandatory in the near term. In the interim, a specific structural inspection has been implemented for this portion of the orbiter structure on the flight vehicles.

It is planned to complete and document this analysis in FY 1988 to complete the subject structural fatigue certification program for the orbiter.

ASAP ITEM: Space Station ability to meet program objectives in a timely manner within current budget allocations. (p. 118)

NASA STATUS: A major review of costing estimates was completed in early 1987. As a result of extensive discussions within the Executive Branch and with the Congress, a revised baseline program was established that satisfactorily matched budgets with program requirements. Further review of program costs by a special committee of the National Research Council is now underway, with completion expected by September 1, 1987. Major steps have been taken, consistent with the concerns expressed by the Panel, but some resource risk remains in all development programs until completion.

ASAP ITEM: NASA should establish a small team composed of current and retired NASA/contractor persons to define the management and technical lessons that can be learned from the space shuttle program and applied to space station to preclude missteps. (p. 118)

NASA STATUS: The Space Station Office is making a continuing commitment to gathering the lessons learned from the shuttle program, as is apparent from many of the comments on points raised in this year's ASAP Report. During the first half of 1987, the Space Station Program Office (SSPO) has been in the process of formation. It has been judged preferable to complete the senior level staffing of the SSPO so that those who must take action to avoid missteps will be able to profit by direct interaction with the small group of experienced people recommended in the Report. During the next few months, the formation of the SSPO complement should be completed, the program support contractor will be selected, and the lessons learned can be handed over directly, rather than through the rather more sterile means of a finished document on lessons learned. Additionally, NASA has funded John L. Casey, Incorporated, to prepare a lessons-learned document which can be used by the space station. John L. Casey, Incorporated, will use retired NASA/contractor personnel to assist, including Mr. Richard Smith and Dr. Robert Gray.

ASAP ITEM: ORBITER STRUCTURAL LIFE CERTIFICATION - An abbreviated conservative analysis should be documented to fulfill the certification program. (p. 118)

NASA STATUS: The fracture/fatigue analysis for LI-36 continues to be deferred to FY 1988 due to budget constraints. The primary work to be completed here is to verify the capability of the subject structure to meet its design life of 100 missions times a factor of 4. In view of the limited number of flights to be accumulated on each orbiter by FY 1988, completion of the LI-36 analysis is not considered to be mandatory in the near term. In the interim, a specific structural inspection has been implemented for this portion of the orbiter structure on the flight vehicles. It is planned to complete and document this analysis in FY 1988 to complete the subject structural fatigue certification program for the orbiter.

ASAP ITEM: It should be noted that a loads calibration program will not be conducted on the orbiter wing, but may be required if the flight results are questionable. (p. 118)

NASA STATUS: A change request is being processed which includes the installation of 18 additional wing strain gauges for improved strain definition. The change request further includes provisions for strain gauge influence coefficient testing and strain gauge calibration. The Level II PRCB plans to review and decide on implementation of this plan in the near future.

ASAP ITEM: ORBITER STRUCTURAL ADEQUACY: "ASKA 6" LOADS/STRESS CYCLE PROGRAM - The Panel agrees with the arbitrary force approach taken at this time. However, the primary load path structure and thermal protection system analysis should be a stand alone report, fully documented and referenced even if the September 30, 1987, end date slips. An operating restriction report and strength summary (external loads and vehicle stress) report for each orbiter should be prepared in order to have quick access to information for making future decisions. (p. 118)

NASA STATUS: Stand alone reports will be issued for the primary structure, the tile system, and the leading edge structural system. The schedule for completion of the 6.0 loads/stress cycle is February 1988.

The operating restrictions for each orbiter are contained in JSC Document 08934, "Shuttle Operational Data Book, Volume 1, Shuttle Systems Performance and Constraints Data."

The operating restriction and loads/stress summary reports are to be included in the post 6.0 loads study effort. The post 6.0 loads studies are part of a number of potential changes and tasks which must be reviewed by Level I/II. The decision as to which changes and tasks are finally approved will be made based on the relative priority (primarily safety) ranking of the individual item and the amount of APA (reserve) funds available to support the change requests.

ASAP ITEM: REDLINES AND MODIFICATION - To provide 85-percent launch probability redlines, the wing modifications should be made, even if slightly conservative, in some structural areas. Redlines on OV-103 and OV-104 should be specifically examined and changed as required. (p. 119)

NASA STATUS: The subject wing modifications (Mod Groups 1, 2, and 3) are being made as required and it is planned to have them in place for the return to flight of each orbiter vehicle.

The redlines have been specifically examined based on the accumulated flight data. The wind persistence factors used to account for changes in the launch winds from those measured 3 hours before launch proved to be underpredicting the actual loads encountered. Consequently, the wing persistence factors have been increased and the prelaunch wind measurement will now be taken 2 hours prior to launch. Final adjustments to the load indicators and redlines will be made when orbiter wing pressure distribution are verified on future OV-102 flights.

ASAP ITEM: BRAKES AND NOSE-WHEEL STEERING

NASA STATUS: In accordance with our plan to increase safety margins, many landing gear system modifications have been considered and a number are being incorporated for the return to flight. Others are still being analyzed or tested for possible incorporation later. First flight modifications include the following:

- Brake instrumentation
- Main landing gear stiff axle
- Hydraulic brake module modifications
- Thick stator/6 orifice brake assembly
- Main landing gear door retract mechanism
- Main landing gear door booster redesign
- Tire pressure monitoring instrumentation
- Anti-skid electrical power redundancy
- Delete brake pressure reduction
- Modification of control box to balance brake pressures
- Load relief for landing gear

Carbon brake development is proceeding with the CDR scheduled for August 1987. A production set will be delivered April 1988, for the Wright-Patterson Air Force Base dynamometer integrated test program. Certification is scheduled to be complete September 1988. The carbon brakes will increase abort braking capability by approximately 50 percent.

Nose-wheel steering has been upgraded to fail safe and is under study for further upgrading to fail operational/fail safe. Developments tests or studies are being conducted on several potential mods including tires with improved wear characteristics and drag chutes. Developments tests are planned this summer on the landing gear skid and wheel roll on rim capability.

ASAP ITEM: "NASA should examine the feasibility of developing data systems under management of the SPC, such as configuration management, that will centralize and augment KSC's operational launch capability." (p. 121)

NASA STATUS: NASA and the SPC are making a major effort to upgrade and integrate the STS information systems related to configuration management and launch processing support. NASA has requested a significant increase in budget for this effort, extending from FY 1988 through FY 1992, and initiated the activity through the SPC. The Problem Reporting and Corrective Action System (PRACA) and other processing related data systems will be improved individually. These and several other processing related information systems will be interconnected and integrated into an overall Shuttle Processing Data Management System (SPDMS) #II. SPDMS II will provide the hardware, software, database and computer-to-computer communications for the accurate, efficient and safe collection, manipulation, dissemination and interchange of shuttle ground processing technical and management information. It will also be interconnected with shuttle information systems at other field centers, such as the Program Compliance Assurance and Status System (PCASS) of the System Integrity Assurance Program (SIAP) at JSC. SPDMS II will be initiated in 1988 with initial emphasis on the OMRSD close-loop accounting related to returning to flight status. Other improvements are scheduled to follow, which will lead to system maturity.

ASAP ITEM: KSC and Shuttle Processing Contractor (SPC) activities re burden of work and flight rate. (p. 122)

NASA STATUS: Open - Panel to follow implementation of NASA and SPC station actions. See previous response p. I-5.

SPC Performance - The processing flow timelines have also been evaluated and replanned to allow the work to be accomplished without significant overtime. The workforce is also being increased essentially across the board. Budget support from FY 1988 through FY 1992 has been requested for the improvement and integration of current information systems into an overall Shuttle Processing Data Management System (SPDMS) #II to relieve the heavy paperwork burden. NASA is also continuing to lay in a good supporting compliment of spare LRUs to support shuttle flights in 1988 and a rate buildup by 1990. NASA has lengthened the flow timelines and increased manpower in order to reduce the work rate per flow in the OPF. We are also planning/requesting budget support for construction of a third OPF bay from 1990 through 1992. This OPF bay is to be in addition to the OMRF, where airframe/structural inspections and major mods are to be performed.

Flight Rate - As a result of the NASA assessment of vehicle processing capability and total work content required to return to flight status, the planned and expected flight rate for Shuttle has been reduced. The development of required capabilities to meet NASA objectives indicates a gradual increase in flight rate to 14 flights per year, which will be achieved no earlier than FY 1994.

E. Referenced Memos from Associate Administrator for Space Flight

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

MAR 24 1986

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Strategy for Safely Returning the Space Shuttle to Flight Status

This memorandum defines the comprehensive strategy and major actions that, when completed, will allow resumption of the NSTS flight schedule. NASA Headquarters (particularly the Office of Space Flight), the OSF centers, the National Space Transportation System (NSTS) program organization and its various contractors will use this guidance to proceed with the realistic, practical actions necessary to return to the NSTS flight schedule with emphasis on flight safety. This guidance is intended to direct planning for the first year of flight while putting into motion those activities required to establish a realistic and an achievable launch rate that will be safely sustainable. We intend to move as quickly as practicable to complete these actions and return to safe and effective operation of the National Space Transportation System.

Guidance for the following subjects is included:

- ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT
- FIRST FLIGHT/FIRST YEAR OPERATIONS
- DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT:

Reassess Entire Program Management Structure and Operation

The NSTS program management philosophy, structure, reporting channels and decision-making process will be thoroughly reviewed and those changes implemented which are required to assure confidence and safety in the overall program, including the commit to launch process. Additionally, the Level I/II/III budget and management relationships will be reviewed to insure that they do not adversely affect the NSTS decision process.

Solid Rocket Motor (SRM) Joint Redesign

A dedicated SRM joint design group will be established at MSFC, with selective participation from other NASA centers and external organizations, to recommend a program plan to quantify the SRM joints problem and to accomplish the SRM joints redesign. The design must be reviewed in detail by the program to include PDR, CDR, DCR, independent analysis, DM-QM testing, and any other factors necessary to assure that the overall SRM is safe to commit to launch. The type and content of post-flight inspections for the redesigned joints and other flight components will be developed in detail, with criteria developed for commitment to the next launch as well as reusability of the specific flight hardware components.

Design Requirements Reverification

A review of the NSTS Design Requirements (Vol. 07700) will be conducted to insure that all systems design requirements are properly defined. This review will be followed by a delta DCR for all program elements to assure the individual projects are in compliance with the requirements.

Complete CIL/OMI Review

All Category 1 and 1R critical items will be subjected to a total review with a complete reapproval process implemented. Those items which are not revalidated by this review must be redesigned, certified, and qualified for flight. The review process will include a review of the OMI's, OMRSD's, and other supporting documentation which is pertinent to the test, checkout, or assembly process of the Category 1 and 1R flight hardware. KSC will continue to be responsible for all OMI's with design center concurrence required for those which affect Category 1 and 1R items. Category 2 and 3 CIL's will be reviewed for reacceptance and to verify their proper categorization.

Complete OMRSD Review

The OMRSD will be reviewed to insure that the requirements defined in it are complete and that the required testing is consistent with the results of the CIL review. Inspection/retest requirements will be modified as necessary to assure flight safety.

Launch/Abort Reassessment

The launch and launch abort rules and philosophy will be assessed to assure that the launch and flight rules, range safety systems/ operational procedures, landing aids, runway configuration and length, performance vs. TAL exposure, abort weights, runway surface, and other landing related capabilities provide an acceptable margin of safety to the vehicle and crew. Additionally, the weather forecasting capability will be reviewed and improved where possible to allow for the most accurate reporting.

FIRST FLIGHT/FIRST YEAR OPERATIONS

First Flight

The subject of first flight mission design will require extensive review to assure that we are proceeding in an orderly, conservative, safe manner. To permit the process to begin, the following specific planning guidance applies to the first planned mission:

- daylight KSC launch
- conservative flight design to minimize TAL exposure
- repeat payload (not a new payload class)
- no waiver on landing weight
- conservative launch/launch abort/landing weather
- NASA-only flight crew
- engine thrust within the experience base
- no active ascent/entry DTO's
- conservative mission rules
- early, stable flight plan with supporting flight software and training load
- daylight EDW landing (lakebed or runway 22)

First Year

The planning for the flight schedule for the first year of operation will reflect a launch rate consistent with this conservative approach. The specific number of flights to be planned for the first year will be developed as soon as possible and will consider KSC and VAFB work flow, software development, controller/crew training, etc. Changes to flight plans, ascent trajectories, manifest, etc., will be minimized in the interest of program stability. Decisions on each launch will be made after thorough review of the previous mission's SRM joint performance, all other specified critical systems performance and resolution of anomalies.

In general, the first year of operation will be maintained within the current flight experience base, and any expansion of the base, including new classes of payloads, will be approved only after very thorough safety review. Specifically, 109 percent thrust levels will not be flown until satisfactory completion of the MPT testing currently being planned, and the first use of the Filament Wound Case will not occur with the first use of 109 percent SSME thrust level. Every effort will be made to conduct the first VAFB flight on an expeditious and safe schedule which supports national security requirements.

DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

The ultimate safe, sustainable flight rate, and the buildup to that rate, will be developed utilizing a "bottoms-up" approach in which all required work for the standard flow as defined in the OMRSD is identified and that work is optimized in relation to the available work force. Factors such as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, work balancing across shifts, etc., will be considered, as well as timely mission planning, flight product development and achievable software delivery capability to support flight controllers and crew training. This development will consider the availability of the third orbiter facility, the availability of spares, as well as the effects of supporting VAFB launch site operations.

THE BOTTOM LINE

The Associate Adminstrator for Space Flight will take the action for reassessment of the NSTS program management structure. The NSTS Program Manager at Johnson Space Center is directed to initiate and coordinate all other actions required to implement this strategy for return to safe Shuttle flight.

I know that the business of space flight can never be made to be totally risk-free, but this conservative return to operations will continue our strong NASA/Industry team effort to recover from the Challenger accident. Many of these items have already been initiated at some level in our organizations, and I am fully aware of the tremendous amount of dedicated work which must be accomplished. I do know that our nation's future in space is dependent on the individuals who must carry this strategy out safely and successfully. Please give this the widest possible distribution to your people. It is they who must understand it, and they who must do it.

Richard H. Truly

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

NOV 5 1986

Reply to Attn of: M

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Organization and Operation of the National Space Transportation System (NSTS) Program

This memorandum defines direction for the organization and operation of the NSTS program. This direction has been reviewed by the NASA Management Study Group led by General Phillips and has the approval of the Administrator. This implements the NASA response to Recommendation II (Shuttle Management Structure) and Recommendation V (Communications) of the Presidential Commission on the Space Shuttle Challenger Accident.

A crucial part of our strategy to safely return the Space Shuttle to flight status, as outlined in my memorandum of March 24, 1986 (and later reinforced by the Presidential Commission), has been a reassessment of the NSTS program management structure and operation. On June 25, 1986, in order to form the basis for a careful assessment of the management of the NSTS and required adjustments, if any, I directed Robert L. Crippen to lead a study of NSTS program operation and organization. This study has been presented to me and, subsequently, reviewed with all incumbent managers of the NSTS program through the project level; all involved field Center Directors (Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), Johnson Space Center (JSC), and National Space Technology Laboratories (NSTL)); and staff members of the Headquarters Office of Space Flight.

Decisions relating to the following program areas have resulted from this deliberation:

- NSTS MANAGEMENT STRUCTURE
- NSTS PROGRAM EXECUTION
- IMPLEMENTATION
- RELATIONSHIP OF THE CENTER DIRECTORS TO THE NSTS PROGRAM

A detailed discussion of each of these subjects follows in this memorandum.

NSTS MANAGEMENT STRUCTURE

Director, NSTS

The position of Director, NSTS, is established. In addition, the Director, NSTS, shall have two Deputies--Deputy Director, NSTS Program, and Deputy Director, NSTS Operations. This triad shall act as a single entity to manage the NSTS program. The Director, NSTS, is at the level of Deputy Associate Administrator and reports directly to me. He will have full responsibility and authority for the operation and conduct of the NSTS program. This will include total program control with full responsibility for budget, schedule, and balancing program content. The Director, NSTS, is responsible for overall program requirements and performance. He shall have sufficient staff/systems engineering support at Headquarters to accomplish this activity. The Director, NSTS, is the approval authority for top level program requirements, critical hardware waivers, and for budget authorization adjustments that exceed a predetermined level.

Deputy Director, NSTS Program

The Deputy Director, NSTS Program, who reports directly to the Director, NSTS, and his senior managers will be Headquarters employees. They are responsible for the day-to-day management and execution of the NSTS program. This includes detailed program planning, direction, and scheduling and STS system configuration management. Other responsibilities include system engineering and integration for the STS vehicle, ground facilities, and cargos. The NSTS Engineering Integration Office, reporting to the Deputy Director, NSTS Program, is established and directly participates with each NSTS project element (Space Shuttle Main Engine, Solid Rocket Booster, External Tank, Orbiter, and Launch and Landing System). The Deputy Director, NSTS Program, will be located at the Johnson Space Center. The JSC Center Director will fully support the personnel and facility requirements of the Deputy Director, NSTS Program.

Deputy Director, NSTS Operations

The Deputy Director, NSTS Operations, a Headquarters employee reporting directly to the Director, NSTS, is responsible for all operational aspects of the missions. This includes final vehicle preparation, mission execution, and return of the vehicle for processing for its next flight. The Deputy Director, NSTS, Operations, will present the Flight Readiness Review (FRR) which will be chaired by the Associate Administrator for Space Flight, manage the final launch decision process, and chair the Mission Management Team (MMT). He will be supported by a small staff located at KSC, MSFC, JSC, and Headquarters. These personnel shall remain employees of their respective Centers but report directly to the Deputy Director, NSTS Operations. The KSC, MSFC, and JSC Center Directors will fully support the facility and personnel requirements of the Deputy Director, NSTS Operations.

NSTS PROGRAM EXECUTION

Flow of NSTS Program Direction and Response

NSTS program direction and response will flow from the Director, NSTS, through the Deputy Director, NSTS Program, to the various Project Managers and vice versa.

In this programmatic chain, the managers of the project elements located at the various field Centers will report to the Deputy Director, NSTS Program. Depending upon individual Center organization, this chain is either direct (such as the Orbiter Project Office at JSC) or via an intermediate office (such as the Shuttle Projects Office at MSFC). The MSFC Shuttle Projects Office is a management integration function and does not preclude direct interaction between the MSFC Project Managers and the Deputy Director, NSTS Program. The Manager, Shuttle Projects Office, located at MSFC, will be a Headquarters employee reporting directly to the Deputy Director, NSTS Program. The MSFC Center Director will fully support the personnel and facility requirements of the Manager, Shuttle Projects Office.

Budget Procedures and Control within the NSTS Program

The NSTS program budget will continue to be submitted through the Center Directors to the Director, NSTS, who will have total funding authority for the program. The Deputy Directors, NSTS Program and NSTS Operations, will each provide an assessment of the budget submittal to the Director, NSTS, as an integral part of the decision process, and their recommendations will be key to the final budget decisions. Following the final budget mark by the Associate Administrator for Space Flight, the Centers will submit a mark implementation plan, reconciling budget and program content, which will also be reviewed and concurred in by the Deputy Directors, NSTS Program and NSTS Operations, then approved by the Director, NSTS.

The Deputy Directors', NSTS Program and NSTS Operations, budgets will be established and managed directly as part of the NSTS budget. Their budgets, although not submitted as part of the Center budgets, will continue to be supported by the Center procurement and financial management organizations.

IMPLEMENTATION

The Director, NSTS, is charged with implementing this direction for the organization and operation of the NSTS program by revising appropriate NASA Management Instructions and program documentation. In addition, the Program Director shall act on the detailed recommendations of the Crippen study, exclusive of the recommendation on Astronauts in Management, which will be acted on by the Associate Administrator for Space Flight.

RELATIONSHIP OF THE CENTER DIRECTORS TO THE NSTS PROGRAM

Responsibilities of the Center Directors to the NSTS Program

As with other programs and projects located at their Centers, the Center Directors are responsible and accountable for the technical excellence and performance of each of the NSTS project elements at their respective Center. Further, the Center Directors will ensure that their institution provides the required support to the NSTS program.

Revitalization of the OSF Management Council

A key element of the ultimate success of the Office of Space Flight is a revitalization of the OSF Management Council. The OSF Management Council will consist of:

Associate Administrator, Office of Space Flight
Director, Marshall Space Flight Center
Director, Kennedy Space Center
Director, Johnson Space Center
Director, National Space Technology Laboratories

The Council will meet on a regular basis, with agendas published in advance, and will oversee all OSF responsibilities, including the NSTS.

Richard H. Truly

For Further Information
Please Contact:

Aerospace Safety Advisory Panel
NASA Headquarters
Code Q-1
Washington, DC 20546