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AEROSPACE SAFETY ADVISORY PANEL

ANNUAL REPORT

COVERING CALENDAR YEAR 1984

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JANUARY 1985

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AEROSPACE SAFETY ADVISORY PANEL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ANNUAL REPORT

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I. EXECUTIVE SUMMARY

Focus of the Aerospace Safety Advisory Panel's activities during 1984 was directed to three broad areas of NASA's responsibilities:

1. The Space Transportation System (STS) operations and evolving program elements,

2. Establishment of the Space Station program organization and issuance of Requests for Proposals to the Aerospace Industry, and

3. NASA's aircraft operations, including research and development flight programs for two advanced "X-type" aircraft.

The majority of the Panel's activities were dominated by the STS.

This report summarizes the Panel's 1984 review activities and resulting observations, and enumerates the Findings and Recommendations which the Panel deem to be appropriate to highlight for NASA management attention. NASA's response to the Panel's 1983 annual report is appended hereto; any matters remaining "open" are noted in this Executive Summary.

Government and industry support of the Aerospace Safety Advisory Panel and its work continues to be excellent, thus enabling the Panel to fulfill its statutory responsibilities.

Panel Meetings

The full Panel, or individuals and smaller groups of Panel members, conducted 36 fact-finding sessions during calendar 1984. These included meetings at six NASA centers and seven contractor sites, and Vandenberg Air Force Base. In addition, the Panel presented testimony before the cognizant committees of the U.S. House of Representatives and U.S. Senate and held other discussions with congressional staff.

Space Transportation System Program

The STS increasing mission frequency places new demands upon both management and the "hands-on" personnel, which will remain at a high level. The standards set during the first 15 safe and successful missions are admirable and commendable. To maintain or even improve upon those standards will require exceptionally perceptive management and disciplined execution of the program. Among the more crucial program precepts, as viewed by the Panel, are: recognition that the STS is a program still in transition from "single event demonstration" stage to "operational" stage, and will remain such until the full operational capabilities (and limitations) are known in quantitative terms based on scientific/engineering proofs; recognition that complacency bred of repetition is an inborn human hazard and conscious steps to avoid same are essential; changes to hardware and software must be controlled to the degree necessary to avoid overloading the processing team's ability to safely implement them; changing contractual and personnel arrangements must be carefully planned in advance; recognition that quality requires strict discipline and is everybody's business everyday; and the logistics system, at a minimum, must be supported by its current level of attention and funding.

The successful Orbital Refueling Demonstration Test conducted during the STS-41G mission, the successful repair and retrieval missions with previously launched satellites, and the successful static firing of the first Filament Wound Case solid rocket development motor (DM-6) are good examples of well constructed and executed adjuncts that support mainline program activities.

Basically the numerous elements comprising the STS ground and flight subsystems have shown good performance and dependability. There are, not unanticipated, some individual components and subsystems which have yet to meet design expectations and are cause for concern as flight rate increases. These include actuators and valves, fluid leaks, instruments, Orbiter brakes, Orbiter external thermal protection tile subsystem and its waterproofing, and Orbiter structural restrictions. Shortages of flight-critical spares continue to require extraordinary measures for each launch preparation.

Taking all of this into account, NASA's planning for the near term use of STS resources and for procedural adaptiveness continues to be thoughtful, thorough, and meets current mission needs during this STS transition period, albeit all the while drawing upon a slim logistics support base.

The Panel has recommended the use of Orbiter-102 as a combined payload carrier and a development vehicle. With its large array of instrumentation and recorders, OV-102 is an ideal vehicle to acquire the quantitative data necessary to fully define the Orbiter's performance capabilities and enhance the data base for future vehicle design. The STS program office concurs and a detailed plan dovetailing mission requirements and R&D needs is being constructed.

Specific Findings and Recommendations relating to the STS program are summarized in Section II of this report and are discussed in greater detail in Appendix D. Topically they concern:

1. STS Launch Processing and Logistics
2. Space Shuttle Main Engines
3. Space Shuttle Solid Rocket Boosters
4. STS Orbiter Structural Life Certification and Adequacy
5. Extra Vehicular Activities (EVA) and Life Sciences
6. Using Orbiter OV-102 in an R&D Role
7. KSC and VAFB Common STS Operations
8. Shuttle/Centaur
9. Radioisotope Thermoelectric Generator (RTG) as a Spacecraft Power Source

Space Station

The Panel was briefed by the program management principals at both JSC and NASA Headquarters on the Space Station concept and plans that are currently being implemented. Early exposure to the program was sought by the Panel to enable it to follow safety-related matters from the conceptual decisions onward through the design, development, and operational stages. The Panel's areas of interest in Space Station will include manned transportation, construction, residency, operations, maintenance, EVA, hazard exposure, escape and rescue, and the safety organization and safety requirements associated with foreign participation. The Panel believes Life Sciences and Space Medicine considerations must be among primary design criteria. It is similarly essential that the Space Station be designed for on-orbit maintenance, as basic design criteria.

NASA Aircraft Operations

The NASA Administrator has provided specific guidance regarding aircraft flight operations policies and procedures to achieve safe, efficient, and productive flight programs. The NASA Headquarters Aircraft Management Office has taken a number of steps to implement the Administrator's directions, including management instructions, revisions to the basic Safety Manual, and assurance of periodic review of each center's flight operations and safety programs.

For the first time in a number of years NASA is directly involved in flight testing "X-type" aircraft, the X-29 and the X-Wing aircraft. Both involve state-of-the-art-and-beyond technical status with attendant experimental flying risks. The Panel has initiated steps to stay abreast of the conduct of these flight testing programs.

NASA Response to ASAP 1983 Annual Report

The Panel's 1983 Annual Report was responded to by NASA with in-depth briefings at JSC and in writing by the Administrator (see Appendix E.). Most of the items are now considered "closed", based on either adequate explanation or implementation or plans to accomplish the activity. There are, however, some items regarding the STS that will continue to be of interest to the Panel.

The Panel continues to believe strongly that there are many benefits to be gained from reducing landing speed of the Orbiter (ref. 1983 Annual Report Conclusion and Recommendation No. 6). While the Panel accepts NASA's response regarding the impracticability of installing a specific solution such as canard control surfaces on the present Orbiter vehicles, the Panel urges NASA to continue to seek other, more readily adaptable solutions.

Other major areas of the STS such as Product Quality, the Orbiter External Thermal Protection System, Orbiter Structural Adequacy, Space Shuttle Main Engine improvement program, and maturing launch operations at Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB) will continue to be followed during 1985. In addition, the Panel will "touch base" on specific hardware items such as Orbiter brakes, anti-skid system, nose-wheel steering, Auxiliary Power Unit, and General Purpose Computer improvement program.

NASA Aircraft Flight Operations are still undergoing change and will be further reviewed by the Panel.

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II. Findings and Recommendations

1. Launch Processing and Logistics

FINDINGS

The transition to the Shuttle Processing Contractor (SPC) was achieved in early 1984. The SPC and NASA are both to be commended for commitment of effort and dedication to success of the concept.

Each subsequent launch processing sequence to date has generated an unexpected burden of modifications, change-outs, repairs, and maintenance tasks. Launch processing has thus been anything but routine and there is no reason to believe that "routine" operations are likely to be achieved in the near future. In effect, the STS is presently in a period of "developmental evolution" wherein a number of key systems will be changed and, one hopes, improved.

The Shuttle Processing Contractor (SPC) is struggling to handle the burden of work associated with each mission. The problems arise in part from difficult engineering tradeoffs and need for sufficient advance planning of modifications to the Orbiter; unexpected replacement of parts; some shortage of qualified spares at KSC; lack of necessary piece parts; some shortage of qualified technicians in certain disciplines, and heavy paperwork burden. The SPC must also assume launch processing responsibilities at Vandenberg Air Force Base using many of the same persons working at KSC.

Although serious, these transitional problems are neither unusual nor unexpected, given the complexity of the STS, its state of continuing development, and the large number of personnel and institutions that must collaborate in launching the Shuttle. The challenge to NASA is to move through this period of "developmental evolution" in a way that makes feasible a sustained period of "operations" into the next century. In other words, efforts and expenditures now to improve the reliability, maintainability, and safety of key STS systems should pay off handsomely in future years.

RECOMMENDATIONS

1. NASA management should continue to allocate the human and financial resources required to maintain acceptable levels of safety in what in many respects is still a developmental program from the point of view of the ultimate use of space as well as the maturity of the system.

2. Modifications to the Orbiter--such as the main engine, structure, avionics, and brakes--should be directed at improving reliability, maintainability, and safety as well as achieving additional increments in performance.

3. NASA management should make a concerted effort to identify and prepare for Orbiter modifications prior to commencement of the launch processing sequence. "Freeze point" discipline must be maintained. Unexpected changes and modifications must be held to a minimum if the Shuttle Processing Contractor (SPC) is to achieve the projected flight rate.

4. Vesting overall Shuttle management in an "operations entity" at NASA Headquarters would help achieve acceptable levels of efficiency, productivity, and schedule reliability during this period of "developmental evolution." The Panel has made this recommendation in past years and NASA management is presently examining this and related issues through the Shuttle Operations Strategic Planning Group, the Smylie Committee.

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5. NASA management would be well advised to avoid advertising the Shuttle as being "operational" in the airline sense when it clearly isn't. More to the point, however, is the fact that Shuttle operations for the next 5 to 10 years are not likely to achieve the "routine" character associated with commercial airline operations. Given this reality, the continuing use of the term "operational" simply compounds the unique management challenge of guiding the STS through this period of "developmental evolution." NASA should continue to focus on making the STS as efficient, productive and reliable as possible while the research and development flights are defining the commercial use of space.

2. Space Shuttle Main Engines (SSME's)

FINDING

The three phase program to improve the SSME that was initiated last year has been restructured so as to provide a long term SSME technology program while staying within the FY 1985 congressional budget. The modified program will not achieve all of the original objectives. It will, however, result in a more reliable and durable engine for operation at 104% Rated Power Level (RPL) thrust with significant margin. Operation at 109% RPL thrust with improved but limited life, under hardware performance constraints will be possible. To achieve additional margin and/or additional life at 109% RPL thrust requires the incorporation of the large-throat main combustion chamber now relegated to the "Precursor" program, a technology-oriented program looking at long-range engineering advancements.

RECOMMENDATION

The modified improvement program should be pursued vigorously. All reasonable effort should be exerted to develop the new hot gas manifold and to incorporate it at the earliest date feasible. Activity to reduce start and shutdown temperature transients should be added to the"Phase 2+" program. Mission planning should continue to consider 104% RPL thrust as the normal operating level for the engines. 109% RPL thrust should be employed only for those missions dependent on the higher thrust and as an abort capability.

3. Space Shuttle Solid Rocket Boosters (SRM/SRB)

FINDING

The Solid Rocket Motor filament wound case may exceed flight to ground system clearance interface limits due to the filament wound case being more flexible than the steel case. Data indicate that the modal frequencies of the filament wound case are even lower than first estimated due to filament wound case joint free-play.

RECOMMENDATION

An analysis and tests be performed on the filament wound case with the total stack to establish lift-off loads and vehicle excursions considering the lower modal frequencies.

4. Orbiter Structural Life Certification and Structural Adequacy

(1) FINDINGS

The structural life certification program for the Orbiter is based on supplemental full-scale tests. However, two extremely important tests on the wing have not yet been conducted which leaves the certification plan incomplete. The full-scale test for these two articles are very expensive and show negligible fatigue damage based on a current simple analysis.

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RECOMMENDATIONS

The Panel agrees with the decision to certify these two articles by analysis. A detailed analysis plan for the two test articles should be developed and implemented to fulfill the certification program for 100 missions.

(2) FINDINGS

The Space Shuttle has to fly in regimes requiring high performance missions with adequate launch probability. The new "ASKA 6.0" Loads/Thermal/Stress cycle program is an important part of certification because flight-measured data show that the wing normal forces were larger and more aft than the ASKA 5.1 and ASKA 5.4 design loads. The ASKA 6.0 Loads/Thermal/Stress cycle will not be completed until 1987. In the meantime, the Orbiter capability assessment (OCA) plan, employing current algorithms, derived from flight test, has been used to make launch decisions using a negative $q\alpha$ profile resulting in a loss of performance. Some wing/fuselage modifications have been made and others have to be completed in order to expand the Orbiter flight trajectory for future flight missions. The flight and wind tunnel aerodynamic data base used for the 6.0 Loads/Thermal Stress cycle (available in 1987) may not be verified by the data from OV-102 instrumented flights. The proposed structural modifications will probably not eliminate the restrictions now being required in flight.

RECOMMENDATIONS

Conduct a systematic review and document the structural differences, safety margins and major logistics impacts for each Orbiter vehicle. In recognition of these differences, baseline the performance envelope for each Orbiter and, as required, determine the trade-offs between any structural/aerodynamics modifications and performance.

5. Space Extra-Vehicular Activities (EVA's) and Life Sciences

FINDING

EVA will continue to be extensively used, both planned and impromptu. The Space Station will require considerable EVA initially for its construction and later for operational activity. While the current suit has performed well, within its limitations, there is need for a new EVA suit with improved flexibility and higher internal operating pressure. Such a concept is in the early development phase in NASA and needs to be funded for further development and possible production as a replacement for the current EVA suit.

RECOMMENDATION

NASA should encourage the development of an advanced higher pressure EVA suit to replace the existing unit.

6. Use of Orbiter-102 in R&D Role

FINDING

In responding to pressures for improved performance there will be a continuing need to expand the STS ascent and Orbiter descent flight envelopes (trajectories) creating the need to obtain flight data measurements relating to structural loads and aerodynamic behavior.

RECOMMENDATION

Orbiter OV-102 is the most suitably instrumented of the Shuttle fleet and should regularly be utilized as a research and development vehicle in addition to its normal mission activities.

7. Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB) Common Operations

FINDING

In the near future, at least in part, common launch crews will be used at both KSC and VAFB and unless the schedules are coordinated conflicts may arise, particularly in the case of DOD's "on demand" launches. The conflicts may not be restricted to schedule but also as to vehicle.

RECOMMENDATION

Until such time as the KSC and VAFB sites have their own launch crews and dedicated Orbiters, the manifesting or scheduling activity should have a procedure to consider the schedule effects on crews who must travel back and forth. Also, attention must be given to the availability of specific Orbiters that may be required by specific missions. This is particularly critical in those cases where the DOD may be required to ask for an unscheduled launch.

8. Shuttle/Centaur

FINDING

The development of Centaur for Shuttle is on a very tight schedule. With but 30% of system weights being actuals, performance margins for the currently planned planetary missions are quite small and expected to decrease. Resolution of issues raised by some of the requests for safety waivers submitted by the Centaur project has not yet been achieved. This is a consequence of additional operational constraints introduced by the inclusion of abort modes for the Orbiter that do not provide the originally specified time for Centaur propellant dumping. There is also an issue concerning the interpretation of certain specifications for some Centaur fluid system components.

RECOMMENDATION

While acknowledging the fact that the issues are being addressed, the Panel urges that the matter of the safety waiver request and the interpretation of specifications be resolved with careful deliberation. The ability to make and incorporate significant design changes for Centaur G' within the time remaining to the planetary opportunity for Galileo is fast diminishing. With the major portion of the Centaur G' qualification test program remaining to be conducted, it would be highly desirable that the Centaur project staff be able to concentrate on insuring that the test requirements are met.

9. Radioisotope Thermoelectric Generators (RTG's) for Galileo and Ulysses Missions

FINDING

Both the planetary Galileo and solar Ulysses missions employ RTG's as the spacecraft power source. Obtaining clearance to fly such nuclear systems is a complex matter both technically and managerially. Relatively recently it was recognized that the capacity of the RTG fuel elements to survive overpressures that might be encountered under certain launch system failure modes might be less than had been anticipated. Concurrently, it was found that there were disagreements about the interpretation of experimental data used to estimate overpressures that would be generated for certain failure modes. Also, the probabilities of the several failure modes had not been agreed upon. During the last half

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of 1984 steps were taken by all organizations involved to resolve the issues in a fully coordinated manner.

RECOMMENDATION

The Panel endorses the proposal made by the ad hoc committee that addressed the issue to improve coordination among the organizations involved by appointing a "single point of contact" on this subject for each organization. Further, the Panel endorses the recommendation to assign prime responsibility for obtaining flight clearance to the science mission center, Jet Propulsion Laboratory (JPL).

10. NASA Aircraft Operations

FINDING

The record over the past year has been good. Progress is being made in providing up-to-date flight standards for both transport (administrative) aircraft and for experimental aircraft. Aircraft operations management resides in the Aircraft Management Office at Headquarters which reports to the Associate Administrator for Management. It is the Agency focal point for all NASA aircraft policy and related matters. The responsibility for development of flight standards is still somewhat fragmented as it is currently left to the various centers to establish and maintain them. The Aircraft Management Office has requested the Intercenter Aircraft Operations Panel to provide a "guidelines" document to serve as the basis for the management instruction to be issued by Headquarters giving central direction covering all NASA aircraft operations.

RECOMMENDATION

The Aircraft Management Office as the Agency focal point for all aircraft operations and related matters should include, if practical, an aviation safety function. The NASA centers would benefit by a single reporting location at Headquarters.

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III. Panel Plans for Calendar Year 1985

Panel Membership

The Panel membership and consultant support has changed somewhat from the previous year. John C. Brizendine is the new Panel Chairman, Charles J. Donlan is a new member, Herbert E. Grier a former Panel Chairman and long-time member will become a Panel consultant in January 1985, and Lt. General Leighton I. Davis has elected to retire from the Panel in December 1984. A new consultant, John P. Reeder, has been brought on in support of Panel's "X" aircraft activities.

After completing 12 years as both a member and Panel Chairman, Herbert E. Grier, will become a consultant to the Panel on January 18, 1985 when his current term is completed. Mr. Grier's knowledge of NASA and its manned space program will continue to support Panel activities as the Space Transportation System transitions to full operations and the Space Station emerges as a full-blown program.

Candidates for membership are being screened at this time.

The following is a brief resume of Mr. Reeder:

Mr. Reeder started with NACA/Langley on June 2, 1938. Following 4-1/2 years of wind-tunnel research, he was trained by NACA/Langley as a research pilot and flew in that capacity with NACA/NASA for 25 years retiring after 42 years with NASA in 1980. He played an active role in the early development of handling qualities requirements for military and civil airplanes and the development of fixes and improvements to World War II aircraft. He performed early exploration of transonic phenomena pioneering in the exploration of the effects of sweepback and rotary wing and V/STOL aerodynamics,

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performance and handling characteristics. During this time, he flew transports for NASA/Langley and NASA Headquarters. He served as Head of Flight Operations, Assistant Chief of the Flight Mechanics and Technology Division, Chief of Research Aircraft Flight Division, and managed the Terminal Configured Vehicle Program. Research pilot experience include 235 different single and multi-engine, civil and military, land and sea aircraft types (40 jet airplanes, 40 fighter types, 61 rotary wing types including British, French and German, and 8 VTOL airplanes).

Mr. Reeder has been author or co-author of about 80 NACA/NASA technical reports and papers and is a Fellow of the Society of Experimental Test Pilots, a Fellow of the American Institute of Aeronautics and Astronautics (AIAA), an Honorary Fellow of the American Helicopter Society (AHS).

Panel Activities for 1985

Specific areas of interest will include the following. These, of course, may be modified as the fact-finding activities develop and as new concerns are brought to the Panel's attention from within NASA as well as external sources:

1. Space Transportation System - The Panel will continue to assess Orbiter structures and functional subsystems; External Tank (only if significant modifications are made to it); continued review of all aspects of the Space Shuttle Main Engine program; Shuttle Processing Contractor/NASA progress at KSC and VAFB as the flight rate increases, hardware ages and a new launch site becomes operational (design modifications to launch facilities to accommodate increased Filament Wound Case/SRB excursions, Centaur integration, bringing the second launch pad into operation at KSC); human factors associated with increased flight rates; Solid Rocket Booster steel case reuse, Filament Wound Case qualification for flight, range

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the FWC, and the potential use of hybrid cases, i.e., mixed FWC and steel. From a logistics viewpoint the Panel expects to look at:

- o The problems associated with obsolescent parts.

- o Adequacy of the publications with regard to such things as the correct reflection of the configurations of each individual Orbiter and the incorporation of the data gained from trouble-shooting experience.

- o The plans to assure spare SSMEs and/or spare high pressure fuel and oxidizer turbopumps to cope with anomalies or use of higher thrust levels.

- o The development of an overall comprehensive maintenance plan for the entire STS system including Orbiter and SSME overhaul up through 1990. Major structural and other modification programs projected for the Orbiter at Palmdale and engine overhaul and update at Rocketdyne would be part of this.

- o Meeting or advancing the 1988 date for final "spares lay-in to support maximum flight rate" and what helps determine this, e.g., manufacturing lead times or limits of present funding?

- o The possibility of transferring "sustaining engineering" activities from JSC to the operating bases at KSC and VAFB earlier than the 1989 period so as to support centralized control over operations.

2. Payloads - The several upper stages in so far as

they affect the mission safety. The Inertial Upper Stage (IUS) under USAF cognizance and the Payload Assist Motors (PAM's) a commercial development will be covered at a low level of activity. The Shuttle/Centaur G' and G vehicles and their support activities will continue to be reviewed. An area of some special interest because of the new and untried aspects is the Tethered Satellite System, as will be any internal/external experiments which can have an effect on safety of the STS missions (e.g., EASE, ACCESS and so on).

3. Space Station - As a developing program it is the Panel's intention to maintain close touch with the NASA organizations involved and, where practical, provide support and achieve a thorough understanding of the underlying concepts and philosophy and how they are expected to be implemented from both a management standpoint and technical approaches. For example, the degree to which "lessons learned" from NASA and commercial operations of highly technical facilities are applied. The evolution of the NASA organization and the relationships with industry will be of interest.

4. NASA Administrative and R&D Aircraft Operations - The Panel will again participate in the Intercenter Aircraft Operations Panel and aircraft safety meetings. Additional time will be spent on the X-29A program as it is flown by NASA personnel in an "X-type" R&D program. The X-Wing program will also be examined with an eye toward assuring that the review system and the safety network are adequate to assure not only first flight safety but subsequent R&D flying safety.

5. As appropriate the Panel will support NASA as it is requested to fulfill its obligation to both NASA and the Congress regarding safety of NASA activities and the public

safety as well.

IV. Appendices

A. Panel Activities Conducted in Calendar year 1984

The Panel continues to operate with fact-finding sessions conducted on the average of three times a month. Individuals, small groups and the Panel focused on the transition period of the Space Shuttle as the flight rate is being increased to meet user's requirements, the emerging Space Station program and various aspects of NASA's administrative and R&D aircraft operations. As always the Panel usually uses scheduled, special and on-going activities at government and contractor installations to minimize the burden placed upon those we meet with and, more importantly, to obtain the most current information and maintain an open communications line with all whom we deal with. The responsiveness of all levels of NASA and others has been most gratifying and shows an excellent working relationship.

The technical and administrative support activities provided by the Panel Staff Director continue to prove invaluable to the Panel in meeting its objectives through continuing in-depth knowledge of the many facets of NASA activities.

The Panel's relationships with the congressional committees and subcommittees and their staffs remains at an excellent level. This provides a feed-back system to assure that the Congress is aware of the Panel's activities and their results and that the congressional requirements are factored into the Panel's fact-finding sessions throughout the year.

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AEROSPACE SAFETY ADVISORY PANEL FACT-FINDING SESSIONS, 1984

SUBJECT	SITE	DATE	MEMBER
Shuttle Turnaround Analysis Group	KSC	1/17-18	Parmet
Intergrated Logistics Panel	KSC	1/25-26	Parmet/ McDonald
Flight Readiness Review for STS-41B	NASA HQ, Downey	1/25	Donlan, Grier, Himmel
Members of Computer Failure Review Team	NASA HQ	1/30-31	Battin
Orbiter Stability & Control	LaRC	1/31-2/1	Davis, Donlan
Annual Meeting w/Administrator	NASA HQ	2/15	Panel
House Testimony	U.S. House of Representatives	2/23	Panel
Senate Testimony	U.S. Senate	2/28	Panel
Space Station Human Factors Meeting	ARC	2/27 - 3/1	McDonald
Space Processing Contract	KSC	3/5-7	Parmet, Stewart
Phase II Shuttle/Centaur Safety Review	JSC	3/13-15	Himmel

Flight Readiness Review for STS-41C	NASA HQ & RI/Downey	3/30	Brizendine, Grier, Donlan
Filament Wound Case Rocket Motor Technical Interchange Meeting	MSFC	4/4-6	Donlan
NASA Aviation Safety Officer's Meeting	Ft. Rucker AL	4/11-18	Davis
Abort, Orbiter Handling Characteristics, Autoland, Space Adaptation Syndrome, JSC Aircraft Operations	JSC	4/24-26	Panel
Integrated Logistics Discussions	NASA HQ	5/2-9	McDonald
NASA Aircraft Operations	ARC	5/3-5	Davis
Safety review on airborne & ground hazards/risk, Critical Design Reviews, Centaur	General Dynamics, San Diego	5/8	Elverum, Himmel
SSME Project	RD/Canoga Park	5/10	Elverum, Himmel
Shuttle Autoland Discussions	JSC	6/8	Battin
Filament Wound Case for Solid Rocket Motor Technical Review &	Hercules/ Thiokol	6/19, 20, 21	Panel

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Space Shuttle Main Engine Anomalies & future program direction	NASA HQ	7/11-12	Himmel
Orbiter Canards & Ditching	LaRC	7/31	Donlan
Panel Testimony	U.S. House of Representatives	8/2	Stewart, Donlan
USAF Space Transportation System Operations	VAFB, CA	8/21-22	Panel
Orbiter	RI/ Palmdale	8/23	Panel
Space Adaption Syndrome Seminar	JSC	8/31 9/1	Parmet
Space Station Orientation	JSC	9/25	Panel
STS Training & Simulations, Aircraft Operations	JSC	9/26	Davis, Battin
Shuttle Processing Contractor/NASA Operations	KSC	9/26	Brizendine, Donlan, McDonald
Centaur Project	LeRC	10/17	Himmel
X-29A Forward Swept Wing, Pre-Flight Readiness Review	DFRC	10/28 - 11/2	Donlan, Parmet

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Panel Activities/ Discussions	Staff of the U.S. Senate & House of Representatives	10/30	Brizendine
Space Shuttle Main Engine Development Program Phase II, IIA	Rocketdyne Canoga Park	11/9	Elverum
Centaur Management Meeting	JSC	11/15	Himmel
Orbiter Life Cycle Certifiation Loads	RI/ Downey	11/16	Stone
Life Sciences	NASA HQ	11/29-30	Parmet
Update on STS, Space Station	NASA HQ	12/5-6	Panel
X-Wing Discussion	NASA HQ	12/17	Reeder, Krone

NOTE: Dr. Himmel was a member of a three-person Special SSME Review team visiting RD/Canoga Park, NASA HQ, and MSFC on a number of occasions.

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B. Panel/Members/Consultants/Staff

Panel Chairman

Mr. John C. Brizendine, Chairman
Formerly President, Douglas Aircraft Company

Members

Dr. Richard H. Battin
Charles Stark Draper Lab.

Mr. Charles Donlan
Formerly, Dep. Assoc. Admin NASA HQ
Consultant, Institute Def. Analysis

Mr. Gerard W. Elverum, Jr.
VP & Gen. Mgr. TRW Space Group

Mr. Herbert E. Grier
Formerly, Senior VP EG&G Inc.

Mr. John F. McDonald
Formerly, VP TigerAir

Mr. Norman R. Parmet
Formerly, VP TWA

Mr. John G. Stewart
Ass't Gen. Mgr. TVA

Mr. Melvin Stone
Formerly, Dir. Structures
Douglas Aircraft Co.

Ex-Officio Member

Dr. Milton A. Silveira
NASA Chief Engineer

Consultants

Dr. Seymour C. Himmel
Formerly, Assoc. Dir. LeRC

Mr. John P. Reeder
Formerly, NASA Research Pilot

Lt. Gen. Leighton I. Davis
USAF (Ret.)

Staff

Mr. Gilbert L. Roth
Staff Director

Miss Susan Webster
Program Support Assistant

C. Panel Correspondence With Congress

There are items that come to the attention of the Panel which are considered valuable enough to warrant providing Panel comments and thoughtful considerations for congressional perusal. The letters which follow are typical of this type of correspondence. It is a part of the process noted in previous sections of this Annual Report noting the open forum, cooperative approach attached to Panel activities.

July 5, 1984

Honorable Slade Gorton, Chairman
Subcommittee on Science, Technology
and Space
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

As Chairman of the Aerospace Safety Advisory Panel I believe it is appropriate to comment to you and your Subcommittee regarding the auto shutdown of the Orbiter Discovery's main engines during launch sequence on June 26, 1984. The Panel believes it is particularly important to do so in view of the negative connotations in the media reporting of the event, which may have created misleading impressions in the minds of the public regarding the safety of the astronaut crew and the soundness of the Space Transportation System.

In fact, the system operated precisely as designed. The launch sequence was stopped automatically when the computer detected a mismatch between actual engine start function signals and the pre-programmed, required function signals. Thus this design safety feature performed as intended to ensure the safety of the crew and the vehicle system. This should bring positive connotations rather than negative ones.

We of the Panel view the Space Transportation System as a program still in transition from the development stage to the operational stage. Due to the nature of its missions and the necessary complexities of its hardware and software, the transition period will continue for some time into the future. It would be a misconception and an unrealistic comparison to expect airline-type operations from the Space Transportation System (although it can be noted that even sophisticated jetliners experience some departure delays and occasional cancellations for technical reasons). The important consideration is that each mission be carried-out safely and successfully. The Space Transportation System safety record is 100 percent thus far, and we are pleased to see the design performing to maintain this record.

Respectfully yours,

John C. Brizendine
Chairman
Aerospace Safety
Advisory Panel

ORIGINAL PAGE IS
OF POOR QUALITY

September 14, 1984

Honorable Harold L. Volkmer
Chairman, Subcommittee on Space
Science and Applications
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

I was pleased to substitute for Chairman John C. Brizendine in presenting the views of NASA's Aerospace Safety Advisory Panel at the Subcommittee's hearing on August 2, 1984, to review Space Shuttle requirements, operations, and future plans. In reviewing the transcript of the hearing, especially the discussion among William A. Anders, representing the NASA Advisory Council, myself, and subcommittee members, I was struck by what at times appeared to be the contradictory assertions that, on the one hand, the Space Shuttle should be viewed as a research and development vehicle for the duration of its operational life and that, on the other hand, NASA should move toward creation of an independent entity within NASA to manage Shuttle commercial operations since NASA's R&D centers were not well suited for this long-term operational responsibility. Given the importance of these roles and relationships for the future of the Space Transportation System, I thought it might be of help to the Subcommittee if I attempted to clarify this line of thinking. These are my personal views although I believe they reflect the general thinking of other Panel members.

In discussing continuing R&D as it relates to the Space Transportation System, several facts must be kept in mind:

1. Many of the original systems and equipment items--especially in the areas of general computers, avionics, and navigation--are obsolete and must be replaced or significantly upgraded.

2. Critical systems, such as the Space Shuttle Main Engines, the auxiliary power units, and the brakes, have performed below expectations and should be upgraded.

3. The complete flight envelope for the Orbiter has not been defined as yet and its definition may indicate the need for structural or other changes to the Orbiter.

4. The need for increased hardware reliability and reduced turnaround time is likely to dictate equipment and system improvements for many years to come.

5. A new generation of upper stages, principally the Centaur and the IUS, must be incorporated in Shuttle operations if the full capability of the STS is to be realized.

These facts indicate clearly why a continuing program of R&D is essential to the safe and efficient operation of the Space Transportation System. In other words, there is no way NASA could responsibly "freeze" all design elements at the present stage of STS maturity. As a consequence, Shuttle operations are not likely to resemble those of a commerical airline in the near future. To assume such highly predictable routine operations is to ignore the important R&D tasks still underway and the uncertainties that inevitably are part of any R&D effort. We can realistically expect elements of this R&D program to continue into the 1990s.

The Shuttle can also provide a useful "test bed" to evaluate various advances in space and astronautics in much the same manner as industrial R&D will be carried on in Spacelab and other missions. For this reason the Panel's statement at the recent hearing noted: "...the Orbiter itself is the only vehicle capable of negotiating the complete velocity and heating encountered during STS missions. This knowledge would help resolve current problems and point up future technical directions. The high technology information which would become available through its use would also be applicable to advanced commerical and military vehicle design."

In short, an adjunct R&D program focused principally on upgrading the operational characteristics and reliability of the Space Shuttle is essential. This program in my view, can be directed most effectively by an entity within NASA charged exclusively with commerical operation of the Space Transportation System. Such an entity, discussed by William Anders and myself during the question and answer period, has been recommended by the Panel in our last two annual reports. NASA has taken several initial steps in this direction.

This operational entity must necessarily draw heavily upon the scientific and engineering expertise of the NASA R&D centers in much the same way that NASA uses outside contractors. However, the R&D agenda maintained by the operational entity would reflect those task related to improved operations, rather than the much wider agenda of innovations that could be supported by the R&D centers relatively free of the discipline of commerical operations. The perspective is one of fundamentally accepting the Space Transportation System as it presenty exists, subject only to the improvements and changes discussed earlier in this letter.

As we noted in our testimony, even an R&D agenda focused on such operational priorities will be substantial and will require considerable funding support in the coming years. This R&D program will move the STS steadily in the direction of greater reliability, greater cost effectiveness and enhanced safety. It will help bring to full operational maturity the world's first reusable space vehicle and set the stage for the next generation. This essential work, in my view, can be directed most effectively by an entity within NASA that has achievement of this operational maturity as its principal mission.

I hope these additional views are of assistance to the Subcommittee in its important review of the STS. If I or other members of the Panel can be of further help, please do not hesitate to call on us.

Sincerely,

John G. Stewart
Member, Aerospace Safety
 Advisory Panel

D. Fact-Finding Results in Calendar Year 1984

1. Space Transportation System Launch Processing and Logistics

While the Space Transportation System (STS) in 1984 demonstrated its unique versatility and usefulness in space through a number of highly successful missions, its problems (e.g., tiles, engine changeouts) on the ground continued to challenge NASA management, the R&D centers, and NASA contractors, especially those responsible for launch processing. Launch and landing operations encompass activities at KSC, VAFB and the many secondary and contingency landing sites as well as reaching into the development centers and their contractors. The Panel has focused on the developmental aspects of the program affecting the management needs of the current period, the hardware/software requirements, resource needs, and the integration of STS operations from the factory to the launch and landing sites. The ultimate management form and the means to achieve it are under study by NASA with no definite approaches as yet selected. Some points, however, have emerged:

o There must be no disruption in the operational support adequacy and ability to safely launch and turnaround the Space Transportation System as currently operating.

o Personnel are a key resource and provisions must be made to "feed in" new people to replace, as necessary, those leaving.

o Hardware and software, as required, will require updating and replacement owing to obsolescence, aging or inability to obtain replacements.

o Traditional organization arrangements, review methodology, handling of payloads, and system certifications cannot remain static but will change with STS maturity and accompanying knowledge and objectives.

o Complacency at any point in the process must be guarded against.

o A specific aspect of the management process which bears further attention are the "Program Freeze Points" and their use. Program freeze points are established at specific intervals during flight processing. Freeze points are defined as those points in time when the design, definition, and content of the cargo, integration hardware/software and flight design, vehicle flight hardware/software, crew activities/stowage and launch site flow are complete. Subsequent to these points, only mandatory changes to the hardware, software or affected documentation are permitted (mandatory changes are those necessary to ensure crew/vehicle safety and/or accomplishment of primary mission objectives). Such freeze points are established for each mission.

o Preparations for contingency landing site (CLS) activities must be planned to meet mission goals and to minimize expenditure of resources which can best be used elsewhere.

o Operational efficiency as measured by such things as turnaround time reduction, hardware increased reliability (increased mean time between failures), increased crew effectiveness, weather predicting, are all a part of operations. Since Day-of-launch winds can affect vehicle aerodynamic loads, better trajectory shaping and load reduction can be accomplished with winds as near to T-0 as possible. The actual "doing" part of launch and landing along with retrieval of SRB's has been proven through the fifteen STS missions to date. However, one area of continuing interest is the impact of flight vehicle and ground equipment hardware and software changes (both generic and mission unique) and procedural changes upon the ground sites, including modifications to the launch constraints or so-called "red-and-blue lines." With regard to any of these the safety impacts continue to be analyzed covering such things as:

- Hazard analysis if a hazard is defined. This includes evaluation of single failure points, redundancy, interaction between "improvement" and interfacing hardware/software/procedures/facilities.

- Many enhancements are to eliminate and/or downgrade current hazards, i.e., accepted risks and controlled hazards.

- The human element, particularly with respect to launch preparations and the turnaround itself, require inspection of "hands-on" impacts which may lead to additional training requirements.

Each mission has provided a more substantial level of experience upon which residual design limitations are being corrected. Significant operational enhancements are being studied for eventual implementation for both mission use and turnaround time optimization. A concerted "lessons learned" exercise is underway with NASA, the SPC, R&D centers, and development contractors to understand and correct the management and engineering problems encountered in launch processing. These commendable actions underscore the developmental nature of the programs at present. This period of "evolutionary maturation" is likely to run to the latter years of this decade. In this regard, a number of developmental aspects of the program are of continuing interest:

o There are a number of hardware items, especially in the avionics arena, that are obsolete and must be replaced or significantly upgraded. Attendant software impacts would, of course, depend upon the equipment. Included here are brakes on the Orbiter which consistently have performed below expectations.

o Achieving the desired Orbiter/stack flight envelope requires further loads definition and Orbiter structural analyses.

o Maintaining and increasing hardware reliability (life) remains a significant part of the program plan and is likely to dictate equipment and system ground and flight improvements for many years to come. This includes the reliability and safety of the so-called "upper stages" which although technically called "payloads" are integrated into the Shuttle operations.

It is reasonable to expect variances and adjustments to plans and timetables based on the above considerations and consequently STS operations are not likely to resemble those of a commerical airline. There is, then, no practical way to "freeze" all of the design elements in the future.

It has been the Panel's opinion for several years that this multi-faceted management challenge would be met most effectively through creation of a STS operations entity to assume overall direction of these developmental and management activities, using the R&D centers in much the same way that NASA draws on the expertise of its development contractors. (See, for example, the letter of Panel member, John G. Stewart to Honorable Harold Volkmer, U.S. House of

Representatives, September 14, 1984 in the Appendix C.)

A complementary area of interest is the pre- and post-flight mission reviews. The Panel notes, as it has in the past (see Annual Report dated January 1982 and January 1983), that the management review processes remain little changed from those used on early missions. With an increased flight rate, maturing systems and hands-on resources, there remains the involvement of a large number of high level management personnel. Changes made to date in this review system have certainly helped but further streamlining should be expected in the future.

Very encouraging progress is evident in gaining control of the complex overall logistics program. The Integrated Logistics Panel (ILP) and its dependent coordination meetings appear to be gaining satisfactory control of the problems. Cooperation between USAF personnel at Vandenberg and NASA personnel at the JSC, KSC, and MSFC centers appears to be excellent and the overall efforts have regained a lot of lost time.

The Panel has previously recommended that a comprehensive maintenance plan be established partly as a system to prevent interruptions in the launch rate through the 1990 period and beyond and partly to provide a more rational basis for the current logistics plan which is now under way. While some elements of maintenance planning are evident there does not yet appear to be a total plan which would include contingencies such as multiple SSME failures or planned withdrawal of an Orbiter for structural fatigue examination or replacement. This sort of maintenance overview may indeed exist and will be examined by the Panel in the future.

The SPC in its operations has uncovered some problems; the most serious of which is shortage of spares. Line replaceable units (units designed for rapid replacement) are in short supply and the only alternative is to "cannibalize" - that is to remove a working component from another Orbiter and pay back the loan when the part becomes available. This is a costly procedure in terms of manhours and delay but the safety implications are those of violating a certified system to get the necessary parts. Another significant problem is that of the workload caused by the incorporation of modifications on the Orbiter at KSC. Even though modifications are scrutinized before the decision is made to incorporate them, further controls may have to be instituted if the launch rate requirements are to be met. The next year or so should see some improvement in logistics and support problems as the SPC program advances satisfactorily.

If OV-105 is ever funded it will have the beneficial effect of providing a "standby vehicle" in the Orbiter fleet but at the same time will sop up most of the available "production spares" thus exacerbating the problems surrounding each individual launch toward the 1990s. The goal is presently some 20 flights per year from KSC and 4 per year from VAFB. There has been a sizable transfer of experienced personnel from KSC to VAFB and we were told that there are about 1200 LSOC people there now.

One of the greatest impediments to rapid turnaround time at KSC - apparently second only to shortage of spares - is the continuing need for modifications. It is true that every modification requirement is most carefully scrutinized by various engineering committees but the cumulative effect of all of these, together with the poor-fit difficulties, is causing considerable distress at the launch site. This entire issue goes back to the question of major overhaul, maintenance planning and the inevitable backlog of modifications will constitute a pacing element. Not much "on-line repair" is being accomplished at KSC which again points out the need for a more definitive maintenance program.

Clearly, the decision has already been made not to include the logistics, supply and support elements of Spacelab, Shuttle/Centaur, Inertial Upper Stage and Payload Assist Module in the ILP considerations. However, it still appears that while funding and control of logistics are separate issues the apparent "hands-off" attitude could well result in launch delays unless they are well stocked with spares. The importance of avoiding launch delays because of payload problems is as important as preserving the logistics support integrity of the STS itself. It is, after all, a system and launch delays have sequential effect upon downstream program where only one launch pad is operational.

2. Space Shuttle Main Engines (SSME's)

The accumulated data on SSME turbomachinery has made it amply clear that the engine is being operated near the upper limits tolerable to the design, and that margins are not sufficient at 109% of nominal power to permit reuse without frequent (every other flight) change out of various turbopump components. This situation is relieved by limiting normal flight operation to 104%. However, even at 104% the engines still have displayed a variety of random wear and damage problems partly associated with design inadequacies and partly associated with manufacturing and maintenance quality issues.

At the end of 1983 a Three-Phase Program was undertaken at Rocketydyne to systematically address these issues. The Phase II and Phase III parts of the program were well-planned to understand the operating limits and to analyze and correct the stressing areas. The basic goal of the program was to improve the operating limits for components showing less than 5000 seconds at 109%, but also in reality to provide improved margins at 104% for higher flight confidence and lower-cost maintenance.

The focused goals of Phase II were to:

- o Increase the HPFTP turbine temperature redline margin from 140°F to 250°F by: improving the HPFTP efficiency, and reducing the turbine back pressure

- o Eliminate the turbine sheet metal cracks

- o Increase second stage blade life on both the HPFTP and HPOTP

- o Increase first stage blade life on HPFTP

- o Correct the liftoff seal bypass leakage problem of the HPFTP

- o Improve rotor stability on HPOTP to increase whirl margin

- o Improve bearing life of the preburner pump and turbine of the HPOTP.

The Phase II program was fully reviewed by some of the Panel members in late 1983 and again in May and November of 1984. The progress made by November 1984 has been impressive. Significant improvements have been made in both the HPFTP and HPOTP. Of real importance however is that in many of the problem areas new fundamental understanding of design criteria have been achieved so that the changes in certain areas represent different and lower-stress operating regimes.

For example, the 500-RPM FPL margin on whirl on the HPOTP has been increased to almost 7000 RPM. This effectively eliminates the problem and provides a known high margin. In another case, a new understanding of the dual turbine bearings dynamic load transfer has resulted in new clearance criteria and reduction to a 12 ball bearing from 13 balls. The reasons for the wear initiation and surface degradation are understood, and the new design clearance provides acceptable operation at all conditions within the designed ball excursion vs radial pre-load region. These and other basic improvements in turbine blade configuration and coatings, welding criteria, etc., have provided a configuration for a new certification program starting in early 1985.

About mid-1984 the Phase III program was eliminated by NASA. It was replaced by a much restricted Phase II+ activity and a longer range technology oriented Advanced Development program. The very limited Phase II+ program does not address most of the items identified in the 1983 Phase III Plan. The only significant change planned for certification is the new hot-gas manifold (HGM), and that HGM will not be introduced into the fleet until about CY 1988. Other key elements of Phase III will be evaluated in a "Precursor" portion of the Advanced Technology program. The elements include single tube heat exchanger with no internal welds, a large throat diameter main combustion chamber and advanced design turbomachinery. Since the "Precursor" program is technology-oriented only and very funds-limited, it is clear it will not really permit timely introduction of the major changes in turbomachinery nor large-diameter Main Combustion Chamber necessary to provide the desired final operating margins at 109%. Although major progress in operating life of components was achieved in the Phase II work, this really relates to replacement cycle-life and not to the environment reductions critical to increasing margins which were planned for Phase III. It is our judgement, therefore, that the SSME should continue to operate with the 104% limit to the greatest extent possible. This will assure that the gains in changeout time are maximized with the attendant cost savings, and that margins are satisfactory for flight reliability.

Only after the Phase II+ and Precursor modifications, particularly the large throat chamber are certified will the goal be achieved of providing operational environments and margins at 109% equal to those now extant at 104%. When that is accomplished one can designate the SSME upgrade as a rated-power engine of 109% of the original rated power level.

Another aspect of the engine improvement process is the desire on the part of NASA to inject a provision for competition into the large liquid rocket field. This is being pursued through advertised requests for proposal on various aspects of the SSME program (i.e., using the current nozzle, engine controller, low pressure pumps and such with new powerheads and high pressure turbomachinery). The idea appears to be that the SSME would be designed to operate at 115% thrust with full life, 30 missions certified with 60 missions demonstrated, and would be capable of operating at, say, 120% thrust with reduced life and being able to throttle to 50% (which can not be done with current engine). Further, with changes to the low pressure pumps and with the same high pressure pumps, there is a possibility of growth to a 130% thrust engine. All of this would require about 8 years for fruition and actual flight use.

3. Space Shuttle Solid Rocket Boosters

The interaction of the Filament Wound Case (FWC) with the total STS stack may cause liftoff loads and vehicle excursions to be in excess of the launch mount capabilities at KSC or VAFB. Even though the loads may be controlled by the use of Belleville spring mounts in the hold-down post at VAFB it still may be more critical than KSC.

The SRM filament wound case segments have already been produced for flight, development and qualification units.

Analysis has been performed using scale model tests to predict modes and frequencies. However, it will take a full scale test to measure vehicle deflections accounting for the FWC joint free-play.

The twang test scheduled for January 1985 derives influence coefficients for primary bending, but does not predict the secondary modes and frequencies during firing and lift-off. It may be possible to calculate or test for the effect of FWC joint free-play and account for secondary modes and frequencies, but it may be worthwhile to measure actual deflections during an SSME firing to provide assured data.

The Panel is concerned about the tight limits placed on the current schedules.

4. Orbiter Structural Adequacy and Life Certification

The Orbiter OV-099 was statically tested for 32 load cases to approximately 1.2 times limit loads (ASKA 5.4 loads cycle). Approximately 33 fatigue/fracture/acoustics supplemental test articles have been completed successfully, except for one which will be completed shortly, in accordance with the certification plan. A scatter factor of four was used in these fatigue and fracture tests. It was decided to delete two tests because of cost and negligible damage shown by analysis due to the fatigue spectra. For instance, tension stress in the lower wing skin is approximately 30,000 psi. The Orbiter is designed for 100 missions whereby a commercial transport is designed for 50,000 flights. The one article, "LI 31", outboard elevon/flapper door/wing portion of rear spar has been tested to 100 missions of acoustic fatigue as test WA-18. The mechanical fatigue and ultimate design load conditions have not been tested. The specimen is now in storage.

The other article, "LI 36", wing/mid-fuselage/aft -fuselage has not been tested for fatigue, ultimate design loads or acoustic environment. The specimen will be put into storage. In this case, the fatigue is negligible, acoustic loads small; however, ultimate strength will not be demonstrated. It is the Panel's opinion that the test of one wing with a simulated carry-through structure is not representative of the wing-fuselage intersection inboard of wing station 167.

It is therefore recommended that these two articles be certified by analysis.

Orbiter Wing and Fuselage Modifications Status:

The Orbiter OV-099 and OV-102 were designed to the early ASKA 5.1 loads. The Orbiter OV-103 and OV-104 were designed to ASKA 5.4 loads with weight savings incorporated only where loads were lower than ASKA 5.1 loads.

The flight test data from flights STS-1 thru STS-5 showed that the wing loads were larger and more aft than design loads during ascent requiring wing modifications at Xo 1191 and wing spar modifications on OV-103 and OV-104.

Leading edge moment-ties were required on all Orbiters due to the increase in down loads in changing the trajectory to more negative $q\alpha$ (dynamic pressure x angle of attack). Mid-fuselage straps were required on all Orbiters due to stringer torsional instability caused by higher thermal gradient during descent. Beef-up of 1307 bulkhead was required on OV-103 and OV-104 due to higher delta pressure. Beef-up of 1307 bulkhead on OV-099 and OV-102, which did not incorporate weight savings, will be decided by further analysis.

Current algorithms derived from flight test data using load indicator gauges defined the increase in wing loads during ascent more precisely resulting in a new package of wing modifications. These modifications include upper wing panels, rib caps, internal and wing/fuselage carry-through structure, fittings and bolts. This package of work is sized for a nominal $q\alpha$ of -2500 but may have to be changed to $q\alpha$ of -3000 if all the modifications can't be accomplished in accordance with required schedules.

Table number one shows the status of Orbiter, wing and fuselage modifications. These modifications will not allow a nominal $q\alpha$ of -1250 to be attained as originally planned therefore further modifications may be required at a later date.

ASKA 6.0 Loads/Thermal/Stress Cycle:

The 6.0 loads/thermal/stress cycle program is proceeding on schedule. The flight measured data are being incorporated into the analysis data base using ascent aerodynamics, ascent loads, descent aeroheating and descent thermal analysis. The large protuberances, Orbiter shape and trajectory regimes have made it difficult to predict wing loads and its distribution within 20 to 30 percent.

The aerodynamic data base used wind tunnel analysis, cold plume simulation and Apollo-Saturn Launch Vehicle fit experience. However, the flight test data showed plume effects larger, normal force larger and more aft, higher local pressures and left/right wing differences.

Operational flight data has been used to check ascent aerodynamics, descent aeroheating and thermal analysis to optimize trajectory shaping, make recommendations for launch and is used to complete the 6.0 loads/thermal/stress cycle. The 6.0 environment, basic math model development, entry external flight loads and landing loads are nearly complete with final data including ascent flight loads available February 8, 1985 for entry into internal loads model.

The internal loads analysis will be available September 15, 1985 with stress analysis margin of safety results available March 15, 1987 and final report August 15, 1987. OV-102 instrumented flight data available in early 1987 will verify the data base used.

Wing airload (predicted pressures) using flight strain gage data shows increase in pressures at upper wing and lower wing station $Y_{O}=250$. This explains why normal loads are larger than design ASKA 5.4 loads. The flight-derived wing indicator gages show excellent predictive capability for shaping trajectories.

Aeroheating/thermal analysis using updated thermal math model shows good correlation with flight data although it is slightly conservative. Temperature gradient predictions are still a problem.

6.0 loads/thermal/stress cycle is proceeding according to plan but can't be accomplished in less time than scheduled. Final verification of data base used for 6.0

analysis will be available from instrumented OV-102 flight data in early 1987, which may require adjustments to the 6.0 loads/thermal/stress analysis.

TABLE 1

ORBITER WING & FUSELAGE MODIFICATIONS STATUS

ORBITER VEHICLE	OV-099	OV-102	OV-102	OV-104
Design loads cycle	5.1	5.1	5.4	5.4
Thermal Protection System Configuration	LRSI/HRSI	LRSI/HRSI	AFRSI	AFRSI
Wing Mod's (1)	Not Req'd	Not Req'd	Req'd	Req'd
Wing Spar Mod's	Not Req'd	Not Req'd	Req'd	Req'd
Wind Mod's (2)	Req'd	Req'd	Req'd	Req'd
Leading Edge Moment Ties	Complete	Req'd	Complete	Complete
Mid-fuse, Straps	Req'd	Req'd	Req'd	Req'd
1307 Bulkh'd	Analysis	Analysis	Req'd	Complete
Instrumentation	Complete	Remain Sched. (1985)	Sched. (1985)	Sched. (1985)
Missions	Ulysses/ Centaur (5/86)			Galileo/ Centaur (5/86)
Major Mod's	KSC	Palmdale 6/84 to 1/85 Many syst chng		Palmdale (Comp 12/84)

(1) Xo 1191 crawl hole doublers & wheel well beef-up

(2) Wing cover, ribs & internal structure

LRSI = Low temperature reusable surface insulation
HRSI = high temperature reusable surface insulation
AFRSI = Advanced felt reusable surface insulation

5. Space Extra Vehicular Activities (EVA's) and Life Sciences

EVA's are becoming a normal part of the STS mission time-lines in support of repair, maintenance, retrieval and specific scientific and technical experiments.

As evidenced by the many and varied EVA operations during 1984 there appears to be no problem with the current methodology which includes the reduction in cabin pressure from 14.7 psia to 10.2 psia hours before donning the suits which are then pressurized to 4.3 psia (pure oxygen). The return is accomplished in the same manner. Space Adaptation Syndrome (SAS) still appears to be a problem for a majority of the crews and may even have affected, for some period, those doing EVA work. It is apparent that the crew training for EVA is thorough, and certainly covers the work to be done each time in meticulous detail, which provides for safety as well. The Extravehicular Mobility/Maneuvering Unit (EMU) or space suit, has instrumentation necessary to status EVA operations. There is some question in-house as to the value of additional instrumentation or enhancements that would allow EMU consumables resource status in order to assess new EVA task and procedures for optimization. Such implementation would require measurement of a few new EMU parameters and telemetry of these new parameters along with some currently measured parameter to a central recording and analysis point. These data could allow understanding of task and procedures design as they affect man's integration into the EVA workplace. Specific parameters to be telemetered include Liquid Cooled Garment inlet and outlet temperatures, O_2 bottle pressure, suit pressure, electro-cardiography, battery power remaining, limiting consumables and possibly others. Some can be obtained through derived parameters such as heart rate and LCG temperatures. We believe this instrumentation would allow the accumulation of a much needed expanded empirical data base.

6. Use of Orbiter 102 in an R&D Role

The Shuttle, despite being pronounced "operational" by NASA after its fourth flight, is far from being "operational" in the sense that term is commonly understood in the airline industry. Many thousands of test flight hours are normally accumulated on a commercial airplane before it is finally certified for routine commercial service. The Shuttle was declared "operational" to announce its availability as a payload carrier vehicle although it is far from "operational" insofar as its measured structural and aerodynamic characteristics are known. For example, wing loads are not yet symmetrical and somewhat higher in certain areas than predicted. Consequently, until more complete flight data is available, Shuttle ascent and descent trajectories must be tailored conservatively to avoid overstressing. If the Shuttle is to attain its maximum performance goals, far more extensive flight data is needed than is now available. Orbiter 102 is the most completely instrumented vehicle of the fleet and is capable of providing the needed data when used as an R&D vehicle. There may be times when it would be worth giving priority to this role over more routine missions. In past flights, data have been lost because of instrumentation system failure. It is suggested, therefore, that because of the small number of flight opportunities the instrumentation (particularly recorders) should be redundant to guard against loss of data in the event of failures.

6a. Use of Canard Surfaces to Reduce Orbiter Landing Speeds and Enhance its Stability

Langley Research Center conducted studies of the use of canards on the Orbiter. As expected the canard configuration does eliminate the undesirable negative lift increment using the current elevon design. The investigations were somewhat limited and did not go into a great number of combinations of Orbiter angle of attack, canard angle of attack, surface areas, and other effects. It would represent a major configuration change requiring years of research and development effort. The Panel is sympathetic with the reluctance of the Shuttle Program Office to undertake such a development when simpler modifications are in the offering. For example, it is the Panel's understanding that the DFRF "TIFS" (Total Inflight Simulator) is to be used to explore some modifications to the Shuttle control system that earlier studies at Ames Research Center indicated could improve the handling qualities by decreasing the pilot induced oscillation (PIO) tendency.

7. KSC and VAFB Common Operations

For some substantial startup time -- years not months -- the rate of Shuttle launches from VAFB will be too low to justify the establishment of a complete launch crew that would be inactive for most of the year. The present plan is to use selected military personnel that have had training at KSC as permanent VAFB personnel and at each launch move the rest of the required crew from the NASA ranks at KSC. None of these people have had the opportunity to train at VAFB and hence the crews must be in residence some appreciable time before each launch, most particularly before the first launch at VAFB.

While this would seem to be a straight forward scheduling job it is complicated by two facts. First, the DOD may be required by circumstances to ask for an unscheduled launch on short notice. Second, the Orbiters are not identical from a structural load capability and certain loads may require certain Orbiters. The scheduling problem is not bad if one formally identified it and is aware of the limitations it may impose on the joint operations. A subsidary but important point is that the launch crews have not trained at VAFB nor has the facility been exercised. The Panel has recommended that an FRF be conducted at VAFB prior to the first launch as a facility and crew certification. A bonus to such a test would be a partial insight into the "Twang" effect on the stack under the VAFB hold-down conditions.

Common ground support equipment interfacing with the space Shuttle vehicle requires special attention so that consistent functional design and such interface characteristics are rigidly maintained since loss of configuration commonality may occur due to KSC or VAFB programmatic requirements.

8. Shuttle/Centaur

The development of the Centaur G & G' stages is progressing only slightly behind schedule. Some changes in interface loads have resulted in redesign of parts of the Centaur. This had contributed to the small performance margins for the G' stage for the planetary missions with but 30% of the Centaur systems weights being based on actual hardware. It is anticipated that further reductions in margin will occur.

Significant progress has been made in the development and qualification test programs although the bulk of the program remains to be accomplished. Among the tests completed are the acoustic test of the G' forward and development adapters and the structural stiffness and 1.2 x limit load tests of the Centaur support structure (CSS). In both of these tests design assumptions were verified.

Preparations are well under way for the major systems tests. These include: test of purge and insulation systems; all-up structural tests of the CSS, tank, adapters and spacecraft mass model under cryogenic conditions, and a modal survey test of the stack just noted.

Electronic systems tests have progressed reasonably well. Some units have completed qualification tests. All Design Evaluation tests (to qualification environmental levels) have been completed satisfactorily. Formal qualification has been delayed because of problems in the procurement of electronic parts and devices.

Three requests for safety waivers had been submitted to the Shuttle Program Office. Two have been approved. The third, dealing with the Centaur fill, drain and dump systems is still under consideration. This system was designed to a requirement that it be able to dump all Centaur propellants in 250 seconds in the event of a Shuttle abort. Since that requirement was established, Orbiter abort modes which do not have 250 seconds available for propellant dump have been identified. The implications of the situation are being assessed. Design changes or operational changes to mitigate the problem are under discussion. The time available to implement any changes is limited because of planetary launch opportunity constraints.

9. Radioisotope Thermoelectric Generator (RTG)

The Panel is aware of issues associated with the Radioisotope Thermal Generator (RTG) to be used on the Galileo and Ulysses spacecraft. The concern is with the possible spread of radioactive material if there is a catastrophic destruction of the SRB's and ET's during pad or ascent phases, or during a landing as the result of an aborted mission. The Panel has not had a review of on-going activities except to note that they are many and diverse in nature. Suffice it to say that the Panel believes that adequate management and technical attention is being paid to RTG concerns.

10. NASA Aircraft Operations

NASA has been long concerned with safety of operations for program support and R&D aircraft. To meet the challenge posed by a "zero accident" desire, the NASA Administrator called for "an action plan that will result in standardized and consistent policies and guidelines to the centers." Such a plan has been developed by the NASA Headquarters Aircraft Management Office and is in process of implementation:

Step 1. Revise and publish the NASA Management Instructions (NMI's) that give guidance for the management of aircraft resources and aircraft related matters (7910.1), that establish policy and guidelines for airworthiness and flight readiness reviews (7910.2), and that govern the management and operation of NASA administrative aircraft. Step 1 was completed in September 1984.

Step 2. Revise and publish volume 7 of the basic safety manual (NHB 1700.1) to provide a step-by-step procedure for use to perform safety hazard analyses. It is planned to send this revision to the centers for comment by June 1985.

Step 3. Cause to be published a memorandum for each Program Associate Administrator having line reponsibility over centers with aircraft directing the implementation of certain policies and procedures which have been established by Headquarters but to date have received limited acceptance by some centers. This step was completed in October 1984.

Step 4. Formalize the policies in step 5 through the publication of a management instruction. Target for completion of the instruction is October 1985. A draft will be ready for review at the February 1985 meeting of the NASA Intercenter Aircraft Operations Panel.

Step 5. Continue to conduct periodic reviews of the center aircraft operations to improve safety. Periodic review of each center's flight operations is ongoing.

The NASA Intercenter Aircraft Operations Panel, composed of the Heads of flight operations at the various centers continue to play a major role in the area of safety assurance. This Panel reports to the Associate Administrator for Management and provides the technical guidance required to centrally manage the diverse missions comprising NASA's flight operations. The Aviation Safety Officer meetings continue to be held to provide concentrated interchange of safety related information. For purposes of repeated emphasis the Panel is particularly interested in two areas affecting accident causes and investigation: human performance, including sensation, perception, cognition, judgement or reactions produced that leads to degrees of human performance; secondly, instrumentation which may be available in case of aircraft problems.

We plan to monitor the X-29A project through its early phases of flight testing. This includes attending appropriate sessions to observe and participate in the evaluation flight test results and future vehicle testing. Plans are to fly the airplane within a limited flight envelope until early May 1985 when the airplane will begin two months of downtime to receive an updated flight control system prior to resuming further flight testing.

New technology items of interest include:

1. Thin super critical (4%) wing with forward sweep.
2. Aerolastic tailoring of wing with composite stressed skin.
3. Relaxed static stability of minus 35%.
4. Close coupled canard with variable incidence.
5. Three horizontal control surfaces, canard wing and strake.
6. Discrete variable camber wing.
7. Triplicated digital flight control system.

E. NASA's Response To Panel's Annual Report Covering CY 1983

The following document, dated August 30, 1984, is the complete letter responding to the Panel's Annual Report dated January 1984. Those items of continuing interest to the Panel are noted in Section I, Executive Summary.

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OF POOR QUALITY

AUG 30 1984

Mr. John C. Brizendine
Chairman, Aerospace Safety
Advisory Panel
6306 Bixby Hill Road
Long Beach, CA 90815

Dear John:

In response to the ASAP's Annual report to NASA, JSC provided the Panel with an in-depth briefing on April 24-26, 1984, on those programmatic and technical issues which the Panel had raised. This in-depth review closed a number of actions, and for some issues the approach to resolve them was presented. This letter presents a top level overview of the status of those issues raised by the Panel and our plans for those areas still open.

As you are well aware, I rely heavily on the Panel's counsel, and I wish to iterate our appreciation. If further information is required, please contact me.

Sincerely,
Original Signed by
James M. Beggs
James M. Beggs
Administrator

Enclosure

1. Product Quality and Utility

ASAP Recommendation:

NASA and contractor employees, both design and production, should now be looking at hardware improvements with operational suitability rather than increased performance as the dominant goal. NASA should give added attention in assisting contractors and subcontractors to achieve high quality products oriented toward such operational suitability.

NASA Response:

I believe that the Panel addresses two subjects in the conclusions and recommendations for product quality and utility, namely, motivation and changes to enhance operations. I totally support the Panel's position on the need to emphasize motivation of the Space Transportation (STS) design team to yield the highest quality product oriented toward operational suitability. To be effective, such an effort must originate with senior management. To emphasize my commitment to quality production, I have established the position of Director of Productivity in the Office of Productivity Improvement and Quality Enhancement. I have personally addressed numerous groups and also have prepared a video tape for use by our subcontractors. We established the NASA Productivity Steering Committee, that I chair, which has Headquarters Associate Administrators and Center Directors as members. Our objective is to examine NASA policy and fundamental changes to improve operations. Our first meeting was held at MSFC on April 26-27, 1984. The conference was attended by more than 200 persons including representatives from 50 different aerospace companies. Our goal is to arrive at new approaches and initiatives to enhance the productivity of NASA and its contractors. Along those lines we have implemented a quality circles program at Headquarters, called NASA Employee Teams (NETS), and at the field centers. They are also in operation at practically all of our major contractors.

Reports so far indicate that the centers and their prime contractors have enthusiastically taken to this initiative. As an example, Level II at JSC has recently issued a directive to all their projects requiring field reviews of hardware to determine the occurrences of unknown failure modes and premature wear, thereby checking qualification and verification program results. The Level III Orbiter Program Office has initiated a Product Quality Improvement Council at Rockwell, which includes Rockwell and their subcontractors. It is "results" oriented and provides meritorious citations where quality and usability have remained at a high level or have shown improvement. The results of these efforts show an overall reduction in the number of nonconformance reports. Rockwell has initiated several personnel and hardware programs to enhance product quality such as their Product Quality Assessment Team that examines the hardware at the subcontractors, and their Employee Motivation Program that rewards plant personnel based upon peer nominations. In addition, all quality plans are approved by the President of the Orbiter Division. Production/productivity quality reviews are held quarterly, thereby providing for lower level information to reach top management.

Other NSTS contractors, i.e., Martin, Thiokol, and Rocketdyne, have similar programs. The key to the overall program has been to involve senior management as well as all disciplines concerned. Rather than provide the Panel with numerous details, I recommend that you include such a discussion item on your agenda when you visit those organizations.

With specific regard to operational suitability, the NSTS program has an on-going hardware enhancement effort the goal of which is to optimize, insofar as possible, KSC's turnaround process. To meet that goal, the Orbiter Project Office continues to process appropriate ground and flight equipment changes to achieve a turnaround time of 35 workdays by the end of September, 1984, which should support our STS flight manifest through FY'86. To provide you an understanding of the extent of our efforts, the following is a partial list of candidate enhancements for study: thermal protection system; deletion of the ammonia boiler system; heater blanket test receptacles; opening the payload bay door without Orbiter power; solid polymer electrolytic fuel cells; OMS/RCS simplification for removal, installation, and test; restriction of connector retest to critical circuits only; Orbiter brakes modification; and upgrading the main engines to reduce maintenance and inspection. Some changes that have already been approved up through the Orbiter level include: Orbital Maneuvering System pod commonality, Aft Reaction Control System tanks commonality, wiring for cargo battery charging, component heater blankets, and moving the desiccator from behind the storage locker.

2. <u>Space Shuttle Main Engine (SSME)</u>

<u>ASAP Recommendation:</u>

The SSME program should proceed with full NASA support and resources to firm up the content and planning for SSME improvement and to implement the program and pursue the objectives vigorously. Retrofit of certified improvements during scheduled or unscheduled removals of the engines is firmly recommended. The plans should continue to include the activity on a full redesign of the high pressure turbomachines that was begun this year. The Aerospace Safety Advisory Panel believes this effort to be necessary to achieve the margin of safety required for routine operations and long life of the engines. As testing to demonstrate margin for operation at the 109%

level will involve operation at thrust levels higher than 109%, there will be temptation to increase the Shuttle performance by utilizing higher thrust. The ASAP advises strongly against such a decision. Operational reliability, and the concomitant safety can be achieved only by operating the engines at thrust levels below the maximum demonstrated in a few tests to show that a margin exists.

NASA Response:

NASA management is fully supportive of SSME improvements. We are committed to the Phase II modifications of the high pressure lox and fuel turbopumps and have presently allocated $75.7M in FY'84 and $55.5M in FY'85 for design, development, and testing to be performed by the engine contractor. As part of the Phase III program, a complete redesign of the lox high pressure pump is underway.

It is the intent of NASA to preserve the margin that is being designed into the Phase III configuration engine for reliability purposes. At this time, we have no plans to conduct flight operations above the 109% thrust throttle settings. We are currently assessing various configuration options for the Phase III engine. We will assess any limitations individually to determine if design action should be undertaken in Phase III to eliminate the restriction.

3. Landing Gear

ASAP Recommendation:

A complete structural and mechanical suitability review of the Shuttle landing gear be made by an engineering organization with commercial transport experience for the purpose of suggesting alternative landing gear configurations and setting target margins for structures and the wheels, brakes, and axles. This review should include but not be limited to:

a. The practicality of converting to a four-wheel main gear truck within the present wheel well.

b. The practicality of putting an extended or extendable strut on the nose gear for the purpose of changing the Orbiter ground attitude (more positive angle of attack), thus relieving the main gear roll-out loads.

c. The feasibility of increasing brake capacity by a major percentage (at least 25%).

d. A thorough review of the weak points on the present gear followed by suggestions for beef-up to bring the margins into partial comparability with the margins of modern transport aircraft in the landing mode.

NASA Response:

In consonance with part of the ASAP recommendation, the Orbiter brake design and operational experience has now been reviewed by an expert committee which included representatives having commercial transport experience. The committee's findings and recommendations were reviewed with the Panel on April 26, 1984, at JSC. The conclusions reached by the committee's board were: (1) no flight safety issue exists with the current design; (2) a number of notable Orbiter brake design characteristics are different from current industry design practices; (3) the cause of brake damage has not been conclusively determined by analysis and confirmed by ground tests, and there is insufficient flight data; and (4) The potential contributors to damage are related to dynamics, hydraulics, mechanical vibration, and chatter.

The committee's board recommendations and status are listed below:

(1) Addition of flight instrumentation. This has been approved for implementation and is being installed on Challenger for its next flight. The redundant instrumentation being used should be sufficient to characterize the brakes' dynamic performance characteristics under actual flight conditions.

(2) Provision for hydraulic system damping. This is now in work at Crane Hydroaire for evaluation to determine the proper orifice sizing.

(3) Modifications of the brake hardware. The 360° saddle has been installed on the two outboard wheels for STS 41-D. Clips for the beryllium drive lugs are being redesigned and will be available for STS-41G. The wheel lug/spline covers are being redesigned for deeper contact between the wheel and brake and will be available for 41G.

(4) Modifications to the crew pedal. This is a simple change which will be accomplished after the crew input on their requirements.

(5) Testing of the carbon liner material. These tests have been conducted to characterize carbon liner material as input data for the math model of the brake system.

(6) Provide measurements of vehicle structure. This has been approved to provide data for the math model.

(7) Develop a math model. This is being accomplished both at JSC and Rockwell. It is expected to be completed in about 6 months.

(8) Perform dynamometer testing at Wright Patterson. Dynamometer testing is being performed at Goodrich.

The four ASAP recommendations have been studied, and the following conclusions were reached:

a. The 4-wheel truck would require a major gear design change and extensive modification to the Orbiter wings to increase the landing gear compartment size. This change would be very expensive, and the vehicle would have to be used as a test bed.

b. The longer nose gear would reduce the tire loads imposed on the main landing gear and improve the single tire rollout capability. However, the tires, along with the wheels and bearings, have been shown to provide adequate margins. Although the longer gear design is possible, it is not simple and would introduce additional failure modes if it were to be fitted within existing structural interfaces. It would cost about $50M and take about three years to develop. However, with recognition to the ASAP point, we are still giving redesign (extension) consideration to provide the optimal load relief for the minimal program impact.

c. It is feasible to increase the brake capacity by 14 percent using the existing wheel. The payoff would not be significant that is, an increase of only several knots in the landing speed would result. The present design will stop the vehicle in about 2500 feet after application of brakes. That additional 14 percent capacity would shorten the landing distance by about 100 feet. Greater increases in brake capacity could be accomplished using structural carbon but would require redesign of the wheel system. The present beryllium carbon brakes are already designed to cover abort landings up to the maximum (240,000 pounds) landing weight allowed. The greatest braking capacity is required during emergency braking which imposes an energy level of 55 million foot-pounds per brake or 220 million foot-pounds for the entire vehicle. The emergency capability of 55 million foot-pounds per wheel has been demonstrated during dynamometer tests at Goodrich. The energy used for the first 10 Shuttle flights has varied from 26.7 to 142.2 million foot pounds per vehicle so a substantial margin exists. A maximum pressure braking test for a short duration of time was conducted on STS 6 the result being the shortest rollout distance achieved

(7180 feet). Clearly we are not pleased that brake damages are being experienced and that operational restrictions are placed upon the crew. However, as mentioned earlier, these are not considered safety critical failures, and steps are being taken to understand and fix the brakes by the addition of flight instrumentation, conduct of additional dynamometer tests, and development of comprehensive dynamic math models. It is quite apparent that there will be some time before the data can be gathered, analyzed, and the corrected. It should be noted that the Orbiter, without the ability to taxi, is unique from aircraft, and correcting this problem will require more patience than with aircraft. With this approach, however, we will have obtained the best possible data, ie., from the flight itself rather than by analysis or simulations.

The ASAP mentioned other concerns in the text regarding the brakes. One of these was the 75 pound force to achieve the maximum 1500 psi brake pressure. The pedal force has been designed to MIL-B-8584C and is consistent with commercial transports. There is activity presently underway to to lighten the pedal force loads.

While it is true that the Orbiter has been designed with less margin of safety than commercial transports, another ASAP concern, it should be observed that the condition for which the design is based is a fully loaded landing weight which is more stringent than the aborted take-off requirements for commercial aircraft. Actually, the fuselage is the load limiting component of the vehicle, not the landing gear.

d. The landing gear has been reviewed numerous times during JSC conducted structure reviews and has adequate margins of safety for all expected flight conditions. It is the program's understanding that the ASAP members present during the April presentation were satisfied with the adequacy of the landing gear.

4. Logistics and Maintenance

ASAP Recommendation a:

A single authority should be established and responsible for all logistic systems.

NASA Response:

The Office of Space Transportation issued on May 1, 1984, the "National Space Transportation System, Space Shuttle Integrated Logistics Support Policy" (SFO PD-110.5.). That document assigns overall responsibility for policy guidance, resource allocation, and management oversight to the Director of Space Shuttle Operations. Level II is responsible for the management of the integrated logistics support and is charged with implementation of the policy. Space Shuttle Program Directive No. 58A, dated March 25, 1983, was prepared to formally establish the NASA/DOD Space Shuttle Integrated Logistics Panel (ILP). They have been meeting on approximately a quarterly basis. The NASA DOD Integrated Logistics Panel (ILP), co-chaired by JSC and USAF Space Division, represents the top authority over combined NASA/USAF logistics programs and policies. JSC, KSC, and MSFC have a centralized Space Shuttle Logistics Manager who is the top authority over Space Shuttle Logistics for that center. Each center's logistics manager is also a member of the ILP and presents center problems and areas of concern to the ILP for resolution. Besides being the ILP co-chairman, the JSC representative is responsible for implementing Space Shuttle policies throughout the Shuttle program.

The logistics policy document has been prepared consistent with the plan to transfer to KSC the various element logistics management functions commencing with the ET and SRM by January 1985 and the Orbiter and SSME by January 1988. These are targeted as the latest dates, and hopefully they can be moved forward.

ASAP Recommendation b:

An overall maintenance plan should be established attempting to provide for at least the next decade.

NASA Response:

A long-term overall maintenance plan is being developed by Level II for the Shuttle system. This plan will become a part of the STS Integrated Operational Launch Site Support Plan to be developed by January 1985.

The "Space Shuttle Integrated Logistics Support Policy" provides a statement in Section 8 relating to the program's maintenance and repair policy. Considerable activity is now being devoted by Level II to updating the Shuttle Maintenance Baseline document (JSC 08151). A Level II change request is scheduled for action in early July and, when approved, will formally control all maintenance sources in accordance with paragraph 8.5 of the policy. The plan is to prepare an "Intermediate and Depot Maintenance Requirements System" (IDMS) relating to maintenance as "Operations and Maintenance Requirement Specification Documents" (OMRSD's) relate to vehicle processing. The objective is to be able to repair any device at KSC in the event that a vendor goes out of business.

ASAP Recommendation c:

The role of the Shuttle Processing Contractor (SPC) in the vital sphere of logistics should be clearly defined as soon as possible.

NASA Response:

A clear and detailed definition of the SPC Logistics roles and responsibilities is available in the Lockheed Space Operations Company's (LSOC) DRL 040 Logistics Support Plan, dated January 10, 1984. A copy has been transmitted to Mr. Roth, ASAP Staff Director, for the Panel's use. Key logistics support objectives are to:

(1) Develop plans for long-term support from off-site maintenance facilities.

(2) Establish a responsive and reliable transportation pipeline to assure timely and damage free movement of SPC material.

(3) Review subcontractor and vendor support for element hardware to ensure that the most economical sources are being used.

(4) Maintain accountability and control of all SPC spares and equipment.

(5) Develop an approach with NASA/KSC/JSC/MSFC to minimize the risk associated with out-of-production flight hardware and associated support equipment.

(6) Provide a logistics support system that uses a common data base for provisioning and reporting that is visible to users at KSC and Vandenberg Launch Site.

(7) Establish provisioning models that will ensure an adequate depth of spare and repair parts to efficiently and economically support the mission model.

(8) Provide a method of tracking repairables in the repair cycle to encourage a timely maintenance repair program that is responsive to need dates and that provides maintenance data for adjustment of range and depth of spare/repair part inventory, adjustment of maintenance activities, and collection/control of maintenance costs.

(9) Develop a logistics launch readiness review system that has a milestone for each mission.

(10) Acquire that logistics operation and maintenance documentation required to accomplish provisioning of spares, overhaul, and repair planning.

ASAP Recommendation d:

Spacelab, Shuttle/Centaur, Inertial Upper Stage, and Payload Assist Module should be included in the logistics plans.

NASA Response:

Although a great deal of progress has been made in support of the Space Shuttle Logistics Elements, additional work needs to be completed before the Space Shuttle carriers are formally integrated into NASA/DOD logistics plans. The decision not to include Spacelab, Inertial Upper Stage, and Payload Assist Module (PAM) in the Integrated Logistics Panel (ILP) charter was briefed to the NSTS Steering Group co-chairman in the NASA/DOD Logistics briefing on January 11, 1984. Both co-chairmen (NASA/DOD) concurred with the "Space Shuttle only" concept of the ILP charter. Under the present concept of the STS operations, incorporation of the carriers into logistics will not be considered until the STS elements have been adequately accommodated. They are, of course, candidates for inclusion at some future date. However, at the present time, logistics, including purchase of spares, is being handled by the sponsoring organizations: Lewis Research Center, the Air Force, and McDonnell Douglas. Since PAM is a commercial venture, it probably will not become a part of the Shuttle logistics system. The uniqueness of the ESA developed and funded Spacelab required a program which was independent of the Shuttle during the R&D phase. The Europeans have funded some spares and maintenance activities which have been supplemented by NASA funding where considered inadequate. As the R&D phase concludes, NASA will gradually phase Spacelab into the Shuttle Integrated Logistics Program, and it is anticipated that KSC will assume full responsibility for their logistics. No date has been established however for completion of the turnover to KSC.

5. Orbiter Structural Loads

ASAP Recommendation:

The Aerospace Safety Advisory Panel recommends that the National Aeronautics and Space Administration expedite the derivation of a new set of loads based on the latest wind tunnel and flight data. The Aerospace Safety Advisory Panel further recommends that renewed efforts be made to validate the final derived structural loads with full-scale flight data.

NASA Response:

We concur with the Panel's recommendation. A new loads cycle (6.0) was initiated in October 1983 and is scheduled to be completed by 1987. This loads cycle will update the Orbiter work to include the latest wind tunnel and flight data to certify the Orbiter for full operational capability. The final derived structural loads will be validated with the full scale flight data.

The OFT (Orbital Flight Test) Program results indicated higher than anticipated loads on the Orbiter wing during ascent, and higher than expected thermal stress during entry. In 1982 JSC initiated the OCA (Orbiter Capability Assessment) to address these issues on a priority basis and to provide interim flight clearance of the structure until a new load/stress cycle could be completed.

Current flights of the Orbiter are supported by the results of OCA, with the exception of the wing. OCA results regarding the wing did not satisfactorily match flight test results. In some cases the differences were significant. Therefore, each Orbiter in the flight inventory is having strain gages installed in the wings to monitor flight load levels, and an additional analytical task has been initiated to obtain a better correlation between aero and structural loads and to conduct wing modifications. The current plan to resolve the wing problem consists of the investigation of near-term structural modifications to achieve flight conditions required at the Western Test Range and the evaluation of aerofixes, such as a spoiler, to achieve flight conditions required in the 1989 timeframe.

6. Orbiter Landing Speed and Pitch Control

ASAP Recommendation:

NASA Headquarters should request Langley Research Center (LaRC) to review the "state of the art" in canard configured aircraft, and prepare briefings to the Aerospace Safety Advisory Panel and NASA Headquarters on the advantages and limitations of canard configurations as applied to the Orbiter. In parallel, Johnson Space Center (JSC) should be asked to explore the practical problems of installing controllable canards on the Orbiters for use in landing.

NASA Response:

In accordance with the ASAP request, Langley Research Center has reviewed the use of canards. They will brief the ASAP and NASA Headquarters in the near future.

JSC has explored the practical problems associated with installing canards on the Orbiter and presented its conclusions to the Panel. During the presentation, a brief background was given, which provided a description of the present Orbiter landing characteristics and a discussion of possible canard benefits. Canard studies in the early design phases of the Orbiter and current Orbiter canard studies were summarized. The practical problems were detailed which showed that to install canards, the program would be required to commit to: redesign of a number of on-board systems, structural redesign of the forward fuselage, re-creation of wind tunnel data bases, and Orbiter reverification. Significant Orbiter down-time and schedule impacts would also result. In summary, the impact of adding canards to the present design are considered prohibitive compared to the benefits. Future generation vehicles will include consideration of canards.

7. Shuttle Processing Contractor (SPC)

ASAP Recommendation:

National Aeronautics and Space Administration should clarify as rapidly as possible its internal organizational arrangements that will support routine operation of the Space Transportation System. Such organizational clarity will be a major factor in achieving the objectives noted above and in assisting the SPC.

NASA Response:

KSC has been reorganized to provide a single, principal interface with the SPC. Previously KSC had three divisions with launch operations responsibilities which have now been combined under one director (Shuttle Management and Operations) reporting to the KSC Center Director. This was accomplished prior to the SPC contract award in order to unify the management of those functions. More recently, the Director of the Shuttle Management and Operations Directorate has been assigned the task of Contract Manager of the SPC to insure close coordination of SPC and civil service personnel for launch operations.

The SPC is now on-board. Although they have been highly successful in hiring personnel who have prior Shuttle experience, the level is not of a degree that precludes NASA involvement. New organizational techniques are used by this contractor, but the management is operating in a takeover mode. What this means is that Lockheed had planned and proposed to provide a service to NASA that had been organized strictly for operations, not taking into account the realities that some integration tasks are still being implemented as we move toward an operational vehicle. The Lockheed proposal presupposed that a logistics program is in place and that no launch vehicle modifications would be necessary. Thus, a straightforward standardized mode of operation was assumed. This, of course, did not permit sufficient leeway for accomplishment of vehicle improvements, and NASA involvement at this time has necessarily become greater than what SPC had anticipated before the award of the SPC contract. After vehicle change activity is reduced, KSC will be in a position to proceed with full operational utility. However, this delay could be to our advantage since we need to carefully deliberate all changes to a successful system.

Lockheed had proposed to implement a large number of innovative changes or techniques for the Shuttle to become operational. These efforts are organized into major program tasks in the areas of management, operations, process planning and control, management systems, process/support operations, work stations, and Vandenberg Launch Site Unique Operations. A description and scheduling of these tasks may be obtained from the KSC document entitled "Description of Evolution Tasks, Initial Baseline," dated March 22, 1984. (The ASAP Staff Director has been given a copy for Panel use). The effort is too extensive to discuss here, and I would invite the Panel to visit KSC to review this subject in depth. Plans and schedules could be addressed at that time. What is significant is that an evolution plan exists and is receiving high level attention. The Director of Shuttle Management and Operations conducts a half-day meeting twice a week on the total program evolution. This management pace is expected to continue into August to assure a sound transition to operations.

In your report's conclusions, the Panel refers to implementation of a unified logistics system and acquiring adequate spares. These are discussed in Recommendation No. 4. The relationship between the Vandenberg Air Force Base and the KSC for Shuttle operations is being worked between the KSC Director of Shuttle Management and Operations and Lt. Gen. McCartney, Commander of Space Division. The Air Force and NASA have agreed upon a policy for the engineering role in which a NASA/AF team directs the contractor. Mr. W. Murphy, formerly of KSC and now detailed to Vandenberg, heads that effort. In that role, NASA reports to the Air Force (Col. Boland). Second level directors are all NASA personnel. The staffing is complete, and personnel are in residence there now. The NASA operations role has not been determined at this time. Lockheed is proposing on a delta effort which would maintain resident force for the facility and would provide travel for the KSC launch team for the small number of Shuttle launches at VAFB. This approach represents our current thinking and should not be construed as the final program plan.

8. Safety of Flight Operations

ASAP Recommendation:

A "Director" or "Chief" of Flight Operations should be identified and should be the focal point of flight safety matters in NASA Headquarters.

This "Director" should serve as a channel of communication from the branch flight operations level at the Centers to whatever administrative level that is necessary to fully resolve a flight safety problem.

National Aeronautics and Space Administration Headquarters, through the "Chief of Flight Operations" and the Intercenter Aircraft Operations Panel, should complement the supervision of flight operations with studies and educational programs aimed at the human factor problem in aviation accidents and assure that appropriate policy documents are issued by Headquarters to meet operational safety needs.

NASA Response:

We have recently brought Mr. Gary Krier to Headquarters to serve as Director of the Aircraft Management Office. His responsibilities comprise overall aircraft operations and management. He is expected to provide the key channel of communication to fully resolve flight operations problems.

The Chief Engineer's Office has been deeply involved in aviation safety oversight roles. That office is directly supporting two major aircraft research programs underway in OAST: the Rotor System Research Aircraft X-Wing Program and the Controlled Impact Demonstration Program. Biennial aircraft operations reviews are conducted at all centers in conjunction with the Intercenter Aircraft Operations Panel (IAOP). At the request of the IAOP, training to the panel in the area of systems safety concepts and procedures was provided. This office is contributing a heightened safety awareness to the centers in providing: guidance on aircraft fire extinguishers, aircraft accident checklists, accident investigation kits, and video tapes, in addition to nearly daily requests on a variety of other safety subjects. Further, the oversight role is enhanced through liaison with other agencies and services, as exemplified by the recent Memorandum of Agreements with the USAF and the Army, to exchange mishap data on aircraft of mutual interest.

At my request, flight operations reviews were conducted by Ecosystems International, Inc. to assess the level of aviation flight safety activities at the Langley Research Center in September of 1982, Johnson Space Center in November of 1982 and

Ames Research Center and its Dryden Flight Facility in December of 1983. The review team found that all the activities reviewed were performing in a highly professional and competent manner.

The other ASAP point was the need to complement the supervision of flight operations with studies and educational programs aimed at the involvement of human factors in accidents. It is becoming increasingly evident that both the physical aspects of the cabin lay-out and the mental make-up of its occupants comprise the total realm of human factors. Over the years, the Agency, as well as others in the aircraft industry, has recognized the importance of the physical part, that is, the placement of switches and controls, the ease and readability of instruments, and other such physical parameters. However, the psychological make-up of personnel has not been as readily acknowledged as an independent contributor, and therefore little is known about it. Research is being conducted by both the FAA and the USAF. NASA monitors the efforts in this field and maintains cognizance of results to date. However, we are unaware of courses on this subject that would be effective in avoiding the type of accidents in which the crew's psychological make-up plays a key role.

We have made progress on two other areas which the Panel addressed in the Annual Report: enhancement of effective communication and upgrading policies and management instructions. I would like to address these two subjects as well.

In facing up to communication inadequacies, I believe that the Agency has now taken significant steps to enhance effective communication on aviation safety and related matters, both up and down the management chain from Headquarters to the flight operations at the centers, as well as laterally at the center level. For one thing, we have increased the frequency with which the IAOP meets to discuss safety issues. This panel met at the USAF Safety Center in December, at JSC in March, and at KSC in June, a fourfold increase over previous history. For another, the IAOP is now sponsoring a newsletter that will publicize on a quarterly basis significant aviation activity.

The Center Aviation Safety Officers (ASO), at a recent ASO meeting conducted at Ft. Rucker, Alabama, praised the significant improvements in intercenter communications. NASA was pleased that one of the ASAP members, Lieutenant General Davis, was able to participate in this meeting and welcomed his participation and inputs.

We have taken measures to insure that communications are supported by appropriate actions to produce more effective implementation of safety. To this end, more emphasis is being placed on operations reviews which include safety. So far, reviews since December 1983 include Dryden, KSC, Wallops and

Lewis. Three other reviews are scheduled this year: Langley, Johnson, and Marshall.

We are in the process of updating the Headquarters aircraft and flight operations policies and management instructions. The status and schedule of each is presented below.

Number	Title	Schedule
NMI 1152.47B	Intercenter Aircraft Panel	Published
NMI 7920.1A	Administrative Aircraft	August 1984
NMI 7910.1B	NASA Aircraft Management	Signed
NMI 7910.2	Airworthiness	Published
NHB 7920.x	Administrative Aircraft Operations Manual	Fall 1984

In addition, we already have updated revisions of the following documents.

NMI 1102.2C	Roles and Responsibilities for the Associate Administrator for Space Technology
NMI 1103.D	Roles and Responsibilities for the Chief Engineer
NMI 1103.C	Roles and Responsibilities for the Associate Administrator for Management Operations
NMI 7900.1B	Delegation of Authority to Approve Policies and Other Matters Related to NASA Aircraft