10/3	HQ	PRCB/FMEA/CIL
10/7	HQ	ET Tumble Valve Waivers
10/16	HQ	SRM Preliminary Design Review
10/17	Seattle,WA	ASAP Activities
10/22-24	Harlingen TX	Intercenter Aircraft Operations Panel
10/21-23	Ames Research Center	X-Wing Flight Readiness Review
10/29	JSC	Probabilistic Risk Assessment
11/7	HQ	Probabilistic Risk Assessment
11/14	JSC	STS Computer Hardware/Software
11/20	HQ	Meeting with NASA Administrator re: ASAP Factfinding
11/20-21	Langley Research Center	Non Destructive Evaluation for Solid Rocket Motor
11/24-25	HQ	Life Sciences Advisory Committee Meeting
12/4-5	KSC	NASA/SPC Launch Processing Operations
12/15-16	JSC	Space Shuttle, Space Station, Computer Hardware/Software
12/17	HQ	Probabilistic Risk Assessment

National Research Council Review Panel Participation

7/7-8	Los Angeles, CA	NRC Solid Rocket Motor Redesign Panel
7/17-18	Morton Thiokol	NRC Solid Rocket Motor Redesign Panel
7/21-22	Washington, DC	NRC Panel on STS Flight Rate and Utilization
8/6-8	KSC/MSFC	NRC Solid Rocket Motor Redesign Panel
8/11-12	Washington, DC	NRC Panel on STS Flight Rate and Utilization

9/10-12	MSFC	NRC Solid Rocket Motor Redesign Panel
9/16-18	Washington, DC	NRC Panel on STS Flight Rate and Utilization
9/22-23	Washington, DC	NRC Criticality Review and Hazard Analysis Audit Panel
10/9-10	Washington, DC	NRC Solid Rocket Motor Redesign Panel
10/27-28	Rocketdyne Canoga Park, CA	NRC Criticality Review and Hazard Analysis Audit Panel
11/10	Washington, DC	NRC Criticality Review and Hazard Analysis Audit Panel
11/20-21	Washington, DC	NRC Solid Rocket Motor Redesign Panel
12/15-16	JSC	NRC Criticality Review and Hazard Analysis Audit Panel

C. Panel Proposed Activities for Calendar Year 1987

The direction to be taken by the Panel is strongly influenced by the NASA and contractor activities associated with the Space Shuttle recovery for reflight, the Space Station Request for Proposal for Phase C/D (now in preparation), and the more significant aeronautic R&D efforts.

As stated before, the Panel's interests and efforts are those which further NASA program/project goals and reduce adverse events associated with meeting those goals. As expected, Panel activities are divided into "on-going" and "new" areas. These are both internally generated by the Panel and those requested by NASA senior management or suggested by the Congress.

1. Space Transportation System/Space Shuttle

- o Continue participation in activities of the National Research Council review panels (SRM redesign and hazard/risk assessments).
- o Review, through factfinding sessions, the more significant actions being taken to return to a safe first reflight of the Space Shuttle. For example, the launch processing activities at KSC, the implementation of the "mandatory for first reflight changes" for all Space Shuttle elements, the implementation and impact of management reorganization at NASA Headquarters and JSC, MSC and KSC, operation of safety organization, etc.
- o As requested by MSFC Director, the Panel will participate in periodic reviews of the Tether Satellite System regarding safety of its operations with the Space Shuttle.
- o Use of Radioisotope Thermoelectric Generator systems on spacecraft to be carried in the Orbiter payload bay.

2. Space Station

- o Space radiation, orbiting debris, extravehicular activities and life science areas as they apply to the Phase C/D efforts.
- o Space Shuttle and Station interfaces with emphasis on safety of combined operations.
- o Escape and rescue approaches.
- o Life sciences applied to on-orbit activities.
- o Implementation of the new Space Station organization and its impact on safety related operations/organizations.

3. Aeronautical Operations

- X-Wing Rotor Systems Research Aircraft flight readiness process, including software validation, safety emphasis and preparation for first flight phase.

- X-29, continue to follow activities to assure that if safety related activities are impacted that they are covered properly.

- Continue participation in the Intercenter Aircraft Operations Panel activities.

- Assess administrative activities associated with research and development and administrative flight activities.

As in the past, the Panel will continue to respond to NASA management and the Congress regarding safety of NASA activities.

D. NASA's RESPONSE TO JANUARY 1986 ANNUAL REPORT

To assure adequate time to develop thorough responses to the many Panel recommendations and comments, NASA has provided three separate response letters covering aeronautical programs, the Space Station, and the Space Shuttle Program (in that order). As in last year's annual report, the Panel notes here the status of each item ("open" or "closed") contained in the NASA letters. Also, the final status of each "open" item from last year's report is provided. Those listed as "closed" means that actions were both planned and essentially completed; those called "open" indicate either plans and/or implementation of required activities are incomplete and/or are not well enough known at this time. The numbering sequence follows that found in the NASA letters.

(Note: The NASA response dealing with the Space Shuttle Program is shown here in final draft form).

SUBJECT	CURRENT STATUS

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

SUBJECT	CURRENT STATUS
o Space Transportation System Operations Contract (STSOC) at JSC goes into effect January 1, 1986. Panel is requested to follow this as they did the SPC at KSC.	OPEN--A continuing activity
o Review the launch constraints being modified in order to increase launch probability and turnaround mods as well.	OPEN--Being done as part of recovery activity
o Comprehensive maintenance plan supposed to have been released September 1985.	OPEN--Being implemented
o Initial lay-in of spares to be completed by October 1987. Status, impact of reduced funding . . . particularly if it affects safety.	OPEN--Being implemented
o SSME precursor test program to be completed during CY 1985.	OPEN--Extended schedule
o Filament Wound Case followup including vehicle excursions, lift-off loads alleviation, lift-off drift concerns, flight control stabililty impacts due to elastic properties, FRF impact on structural adequacy of "single-use" first flight segments.	CLOSED--Program shutdown with delivery of six sets No flight, or demon-strations expected in near future.
o Results of Rockwell's detailed fracture/fatigue analyses for test article LI-36 (wing/mid-fuselage/aft-fuselage structure being conducted June 1985 to January 1986.	OPEN--Deferred to FY 1988
o Shuttle/Centaur to adequately conduct tests within current schedule and the availability of resultant analyses is a concern. (OPEN)	CLOSED--Program cancelled

2. STATUS OF ITEMS COVERED IN EACH OF THREE RESPONSES INCLUDED IN THIS SECTION COVERING ANNUAL REPORT DATED JANUARY 1986.

a. Aeronautical Programs, letter from Dr. Fletcher to Norman R. Parmet, September 24, 1986.

SUBJECT	CURRENT STATUS
(1) NASA should appoint a qualified operations manager as head of Aircraft Management Office. Reduce time to produce and approve flight operations documents.	CLOSED

(2) Current status of X-29A and X-wing research aircraft programs and associated safety activities.	CLOSED

b. Pressure Suits, Space Station, and Space Debris, letter from Dr. Fletcher to Joseph F. Sutter, January 9, 1987.

(1) Extravehicular Activities (EVA)/ Space Suits	OPEN--NASA activities ongoing
o NASA support of the development of an advanced flexible higher pressure suit.	
o NASA support of development of necessary data to establish, with confidence, what maximum stay in space should be.	OPEN--NASA activities ongoing
(2) Space Station	
o NASA should re-examine the Space Station integration resources required to ensure organization and human resources are sufficient.	CLOSED--New organization and work packages using SE&I contractor
o Space Station ability to meet program objectives in a timely manner within current budget allocations.	OPEN
o NASA should determine possible means to alleviate the payload bay interface environment and design requirements which drive some of the Space Station element and "user" designs.	CLOSED
o NASA should establish a small team composed of current and retired NASA/contractor persons to define the management and technical lessons that can be learned from Space Shuttle program and applied to Space Station to preclude missteps.	OPEN
(3) Space Junk (Debris)	
"Efforts to resolve this issue internationally must be intensified before it moves from the concern to the problem condition. Any solution must consider not only the large trackable units but the small debris that represents an	CLOSED--Although not completely implemented, proper attention is being given

unavoidable collision hazard. The Panel would urge NASA through appropriate channels to establish an international consideration of this issue before it becomes a critical problem."

c. Space Transportation System (STS), letter from Dr. Fletcher to Joseph F. Sutter,

I. Orbiter

A. Orbiter structural life certification

o An abbreviated conservative analysis should be documented to fulfill the certification program.	OPEN--To be accomplished in FY 1988
o It should be noted that a loads calibration program will not be conducted on the Orbiter wing, but may be required if the flight results are questionable.	OPEN--NASA plans to conduct a loads calibration program on the OV-102 wing prior to its next flight.
o Other structural components, e.g., the crew module, will not be well documented.	CLOSED--The crew module is excluded from the "structural article" by design and, therefore, will not be included in the structural article certification documentation.

B. Orbiter Structural Adequacy: "ASKA 6" Loads/Stress Cycle Program

The Panel agrees with the arbitrary force approach taken at this time. However, the primary load path structure and thermal protection system analysis should be a stand-alone report, fully documented and referenced even if the September 30, 1987, end date slips. An operating restriction report and strength summary (external loads and vehicle stress) report for each Orbiter should be prepared in order to have quick access to information for making future decisions.	OPEN--Until 6.0 loads/stress cycle work is complete

C. Redlines and Modifications

To provide 85-percent launch probability redlines, the wing modifications should be made, even if slightly conservative, in some structural areas. Redlines on OV-103 and OV-104 should be specifically examined and changed as required.	OPEN--Launch redlines being reviewed

D. Orbiter Avionics and Software

o Monitoring of applications software and procurement of new GPCs.	CLOSED
o Mass Memory Unit upgrade.	CLOSED--Upgrade on indefinite hold

E. Brakes and Nose-Wheel Steering	OPEN--Redesign, tests, procurement still in process
F. Landing Handling Qualities	CLOSED

G. Automation

If the automatic Orbiter flight system for ascent is relied upon, then why not the automated flight system for landing?	CLOSED--Auto land available as required

H. Fuel Cells

Review to ensure that design of accessories is conservative.	CLOSED--Additional studies underway to reconfirm and hardware upgrade in process

II. Propulsion

A. Space Shuttle Main Engine

o The recertification approach selected by NASA permits different parts of the engine to be "certified" for different flight times. This results in a somewhat questionable data base regarding true engine	CLOSED--The philosphy, which has been adopted by the program, is to test for a given number of cycles and replace the flight motors after half of those cycles have

configuration operating margins and valid Mean-Time-Between-Replacement values.	been expended. NASA approved in August 1986 the alternate pump program to provide a new, longer life pump with much higher safety margins. The desirable goal would be to perform limited testing to show margin and this is under consideration.
o The Panel recommends that the engine be operated at power levels above 104% of rated power only when mandatory. Also, when engine operation above 104% is necessary, the power level selected be only the value required for the particular mission and not taken all the way to 109% except when mandatory.	CLOSED--The 109% used for routine flights will be no earlier than 1993. Until then, 109% is for emergency mode only.
o The Phase II development and demonstration program should provide a data base for the modified turbopumps that can be used to estimate new Mean-Time-Before-Replacement criteria for the turbomachinery.	CLOSED
o We further recommend that the "precursor" (future) program improvements be supported at a level such that they can in fact be incorporated as soon as possible into the flight engines.	CLOSED--The precursor program will have to be delayed until the design and certification of critical items required for the first flight are accomplished. At that time (mid to-late 1988), NASA hopes to accomplish the testing of the precursor candidates.

B. Solid Rocket Boosters

o The Solid Rocket Booster holddown bolt calibration tests should be carefully examined at this time to aid in obtaining meaningful final test results.	CLOSED
o Filament Wound Case rocket motor activities. Appropriate Analyses	CLOSED--FWC Project suspended and such analyses

and tests have to be conducted prior to flight use of these motor segments.	and tests appropriate to shutdown are in process.
o A search is underway for an insulation replacement since the use of asbestos is no longer legal. This is a real concern...	CLOSED--The overall schedule and development/ quality plan for the replacement of the internal insulation and other asbestos-containing materials in the Shuttle SRM is being updated and is available.

III. STS Operations

A. Flight Crew Training

o "NASA must commit the funds in a timely manner to ensure an adequately sized fleet of training aircraft to meet the flight crew training needs, without reduction or compromise to the Orbiter flight training syllabus."	CLOSED--Plans are being formulated to purchase and modify an additional (4th) aircraft that may be available in FY 1988.

B. Logistics and Launch Processing

o NASA management should monitor closely the effects of the recent reorganization at KSC to make sure that it has accelerated and simplified management of launch processing.	CLOSED--A continuous activity on part of NASA and the Panel.
o "NASA should examine the feasibility of developing data systems under management of the SPC, such as configuration management, that will centralize and augment KSC's operational launch capability."	OPEN--In work
o NASA should continue to give high priority to acquisition of spare parts and to upgrade the reliability (planned life) of hardware.	CLOSED--In work. Panel will continue to follow.
o NASA should explore whether better coordination could be achieved between those persons	CLOSED--In work. Panel will continue to follow.

determining manifests for specific flights and those persons charged with launch processing.	
o Facilities should be provided to minimize turnaround times of the Shuttle and Line Replaceable Units (LRUs).	CLOSED--Orbiter Maintenance and Refurbishment Facility being constructed. Plans to implement LRU repair facility.
o VAFB Launch Complex development issues.	CLOSED--VAFB moth-balled until at least 1991
o KSC and Shuttle Processing Contractor (SPC) activities re burden of work and flight rate.	OPEN--Panel to follow implementation of NASA and SPC Station actions

IV. Payload Interface Standardization

ASAP Recommendations: "There will always be peculiar requirements for special payloads, but insofar as is feasible, there should be increasing effort to preparing and carrying payloads in a standardized fashion."	CLOSED--Panel will reexamine later. Current NASA system is stated as providing a generic system to accommodate complex and simple payloads.

V. Shuttle Centaur	CLOSED--Project cancelled. However, this decision should not be interpreted as total exclusion of the use of cryogenic stages as Shuttle payloads on future flights.

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

SEP 24 1986

Mr. Norman R. Parmet
Acting Chairman
Aerospace Safety Advisory Panel
5907 Sunrise Drive
Fairway, KS 66205

Dear Norm:

Inasmuch as the ASAP's presentation to NASA on the results of the 1985 investigations was made before my nomination to Congress as NASA Administrator, I did not receive the benefit of your annual presentation. I have taken the opportunity, however, to review the Panel's findings and recommendations which are provided in the 1985 Annual ASAP Report.

The Panel's observations and recommendations to NASA are welcome, and we will respond to them with a view toward positive accomplishments. Due to the changes which NASA has been experiencing this year, multiple response letters to the 1985 report covering the aeronautical programs, the Space Station, and the Space Shuttle Program will be forthcoming. The enclosure provides the first NASA response to ASAP's recommendations, namely, those for the aeronautical programs. In addition, I am including commentary on the appropriate ASAP discussions which are provided within the fact finding section of the 1985 Annual Report.

With respect to the aeronautical reviews during 1985, the Aircraft Management Office (AMO) and the Intercenter Aircraft Operations Panel (IAOP) have enjoyed a professional liaison with both you and Gil. You have been a welcome addition to all of the IAOP meetings, as well as center aircraft operations reviews. Both the AMO and the IAOP look forward to a continuing dialogue with ASAP. I would like to thank ASAP for its recommendations, and I believe that the AMO's redefined role and delivered products during 1985 clearly demonstrate the incorporation and implementation of previous ASAP recommendations as well as those for 1985.

I would like to express my appreciation for your assuming the chair position on short notice and keeping the panel's activities moving forward. NASA looks forward to the Panel's participation as we conduct crucial reviews toward regaining a flight-worthy Space Transportation System. The panel's ideas and recommendations are appreciated and are carefully considered.

Sincerely,

James C. Fletcher
Administrator

Enclosure

NASA RESPONSE TO THE 1985 ANNUAL ASAP REPORT
APPENDIX 1: E. AIRCRAFT OPERATIONS

ASAP RECOMMENDATIONS:
NASA should appoint, as soon as possible, a qualified operations manager as head of the Aircraft Management Office (AMO). Determine methods to reduce the time it takes to obtain review and approval for critical flight operations guidelines and policies which are generated at Headquarters.

NASA Response:
Mr. Elwood P. Driver has recently been selected to fill the position of Director, Aircraft Management Office. Mr. Gerald T. McCarthy serves as the office's Deputy Director. Actually, a director, as well as two aviation safety professionals, had been selected for the AMO during 1985. Two highly qualified engineers, specializing in the areas of aviation safety and human performance, were brought on board. In August, the Director-designee of the office declined the position after having previously accepted it. The position was readvertised in October, and a Senior Executive Service (SES) panel reviewed the applications of the candidates. Due to the NASA hiring freeze, the Associate Administrator for Management had been unable to offer the position to a selected candidate. Even though the AMO had been without a nominal director during this time, however, two points should be emphasized. First, there had been an Acting Director designated. Second, and perhaps more significant, not only were the functions of the AMO successfully accomplished by the staff working in the office at the time, but also they were significantly enhanced.

In response to previous recommendations made by the ASAP and by ECOsystems center reviews, the AMO underwent a redefinition and reemphasis of role and functional implementation during 1985. There was a significant enhancement in the office's central coordination of aircraft operations policy and standardization, as well as flight operations reviews and aviation safety management. The AMO, which is the Headquarters focal point for agencywide aircraft operations, management, and operational aviation safety, is responsible for, and has been effecting the following principal functions during 1985:

1. Developing and issuing NASA policy guidelines governing aircraft operation, operational safety, aircraft maintenance, flight crew qualifications, and related training activities;

2. Reviewing and evaluating the adequacy of field installations organizations and procedures for aircraft operations;

3. Coordinating Headquarters' reviews and evaluations of proposed acquisitions, reclassifications, reassignments, and dispositions of NASA-controlled aircraft;

4. Providing institutional and functional management of all NASA administrative aircraft;

5. Developing and implementing a NASA Aviation Safety Program;

6. Developing and establishing guidelines for implementation of human performance concepts in NASA flight operations;

7. Supporting activities of the Intercenter Aircraft Operations Panel (IAOP);

8. Maintaining liaison with other agencies and the private sector on matters pertaining to aircraft operations (FAA, DOD, NTSB, ATA, NBAA, etc).

We recognized the need to reduce the documentation approval time and shared the ASAP's concerns. Stricter compliance with NASA Management Instructions (NMI), as well as the Headquarters' institution of the NASA Priority System, have significantly reduced the time required to obtain review and approval for aircraft operations guidelines and policies. There have been numerous products during this time period which demonstrate the significant enhancement of this office's management of NASA aircraft operations. Some of the AMO products in 1985 were as follows:

1. Established first NASA guidelines on pilot aging, aviation medical standards, flight approval authority, and maintenance inspections. Although the guidelines were not published as an NMI during 1985, due to the extensive NASA coordination cycle, the procedures outlined in the guidelines were established through directive letters from the Associate Administrator for the Office of Management in 1984 and were published as NMI 7910.3 in April 1986.

2. Published in January 1986, NASA Handbook (NHB) 7920.3, "NASA Administrative Operations Manual."

3. Established the AMO as focal point for NASA operational aviation safety and aircraft operations incident reporting. For example, the AMO represented Headquarters in the Convair 990 aircraft and Challenger accident investigations, as well as aircraft incident reporting.

4. Developed an Aviation Safety Program Plan.

5. Developed an Aircraft Operations Human Performance Program Plan.

6. Provided first AMO aviation safety/human performance evaluations during X-Wing operational and safety reviews at Ames Research Center.

7. Enhanced activities and effectiveness of the IAOP including: establishment of a new maintenance subpanel; reduced production time of IAOP meeting minutes and center review reports; development of IAOP Center Review Schedule through 1987; and establishment of a recommended follow-up tracking system.

8. Developed an action plan for the installation of crash recorders on NASA aircraft.

9. Documented the need to upgrade Dryden Flight Research Facility chase aircraft, resulting in the current acquisition of F-18's from the Navy.

10. Developed a five-year plan for the replacement of the Gulfstream 1 aircraft.

11. Reduced AMO written response time to ECOsystems recommendations.

The ASAP suggests in their fact finding section of the report that the ideal management structure for flight operations would be an office which reports directly to the Administrator or the Deputy Administrator. That office's function would encompass all aircraft operations, whether administrative, developmental, or research. While this would accomplish ASAP's objective of aircraft operations budget centralization, it would remove the knowledgeable and responsible research and development office from the program accountability of the flight test programs, which they now have, and would place the flight test operations program under an office which is more attuned to standard operational aircraft operations. The AMO is not staffed to undertake enhanced NASA operational functions. We believe it is in NASA's interest for the responsible research Center Director and program Associate Administrator to retain the present accountability. The present system is functioning satisfactorily.

APPENDIX 2: RESEARCH AIRCRAFT PROGRAMS

We are pleased that the Panel considers that NASA has been exercising the appropriate safety initiatives on our research aircraft programs and, therefore, no recommendations were formally provided in the "Findings and Recommendations" section of your report. It is appropriate, however, for us to address your comments provided within the "Fact-Finding Results of Calendar Year 1985." Before I discuss the two aircraft research programs, it is important to note that both programs, as well as other NASA programs, use composite materials for primary structure. We have been experiencing some problems with quality of the composites, particularly with delaminations. The Panel's investigations and insight into this subject are welcome.

a. X-29A Research Aircraft

The Panel should be made aware that the 80 percent operational design limitations will remain as the limiting load factor. We elected to maintain this limit rather than perform structural load tests.

We agree with the Panel that speed brakes would be desirable and would potentially enhance overall safety of the flight aircraft. They were rejected at the time of the program's initiation for several reasons. The dominating reason being the implementation cost. It was concluded that the proposed flight program could be safely accomplished without speed brakes. Since that time, the scope of the program has been changed. A follow-on program has now been approved which will significantly extend the duration and complexity of the flight program. With this in mind, it is desirable to revisit the speed brake issue. We now plan to fund a design study to determine the possible speed brake options available and their associated costs. Once these results are available, we will decide if speed brakes should be added to the X-29A.

b. X-Wing Rotor Systems Research Aircraft (RSRA)

With respect to program schedules, the milestones are presently holding firm. Roll-out is planned for August 1986; the first flight test without the rotor is planned for October 1986. However, if uncertainties arise with regard to safety, we will not hesitate to move the milestones to a later date. A decision has recently been made to accomplish all flight work at the Dryden Flight Research Facility. This revision to the flight test plan should simplify operations and thereby enhance safety. A Flight Readiness Review (FRR) Board has been established to resolve all safety issues prior to the first flight. As the Panel observed, there are many aspects and organizations involved with the overall safety program. Some of these are independent of the principal program activity which we consider to be healthy. You should be aware that the Ames Research Center Director, whom I hold fully accountable for the safety of this vehicle, provides the focus for these safety activities.

Your discussion regarding aeroelastic flutter and divergence was very interesting and I deeply share your concern. The model testing is late in supporting the fixed wing FRR, but I assure you that the first flight will not occur until I am satisfied that this matter is technically resolved and agreed upon by the particular NASA technical community which has the expertise. I would also appreciate the panel's review and advice on this matter prior to first flight commitment.

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JAN 9 - 1987

Mr. Joseph Sutter
Chairman
Aerospace Safety Advisory Panel
9311 Fauntleroy Way
Seattle, WA 98131

Dear Joe:

As promised in my earlier letter to Norm Parmet dated September 24, 1986, I am providing NASA's second response to the ASAP's 1985 Annual Report. The content of this response covers the pressure suits, Space Station and space debris. The Space Station is rapidly evolving not only because of its concluding the Phase B preliminary design, but also because of changes mandated as a consequence of the Challenger accident. Our detailed response is provided in the enclosure, but I would like to state in summary that NASA is accomplishing the Panel's recommendations.

I look forward to your comments and recommendations in the 1986 report, as a measure against the progress which NASA is making during our recovery from the Challenger accident. Your suggestions for changes and improvements will receive the utmost attention by NASA. Our response to the sections dealing with the Space Shuttle Program is forthcoming.

Sincerely,

James C. Fletcher
Administrator

Enclosure

1. "C. Extravehicular Activities (EVA)/Space Suits"

ASAP Recommendations:

"NASA should continue to support the development of a more flexible, higher pressure EVA suit and fund the development in an appropriate manner."

Other ASAP References to EVA/Space Suits:

1. Executive Summary. Page 3. "STS-Payload Related Issues."

   "It also points up the continuing need for a more flexible space suit or alternatively an end-of-arm manipulator to perform the normal hand functions--perhaps both."

2. "Fact-finding Results of Calendar Year 1985," "4. Life Sciences," pages 60-61.

   "However, there is a perceived need for a more flexible suit in the future that has the capability of operating at a higher pressure than the current suit and its development should be encouraged so that it can succeed the current suit on an attrition basis."

   "NASA's management must continue to support the efforts of the life sciences group to develop the necessary data to establish, with confidence, what the maximum stay in space should be."

   "Perhaps the way to go is not to change suit pressure but to design these arms and legs as replacement for the current ones."

NASA Response:

NASA is continuing to support the study of advanced EVA space suits and a regenerative, non-venting, portable life support system. Alternative higher pressure space suit designs with expanded capabilities are being pursued at the Johnson Space Center and Ames Research Center. The intent is to identify the advantages of alternative design approaches and, if feasible, to pursue a full scale development of the optimized design.

There is not, however, total agreement within NASA on the need for or the desirability of a high pressure suit. The Experimental Assembly of Structure in Extravehicular Activity (EASE) and Assembly Concept for Construction of Erectable Space Structures (ACCESS) experiments flown on STS-61B proved that improvements in glove design for improved ease of operation and wear characteristics will be essential. Clearly, the operational flexibility of a glove operating at twice the present pressure of the current design offers a challenge that needs to be met. An improved operational glove is essential to the successful EVA operations which will be placed upon the crew in the Space Station era. I am committed to the achievement of that goal, regardless of the suit's operational pressure. We are presently evaluating two competitive glove designs, one by ILC and the other by the David Clark Company. Ames is investigating an end effector which would assist in hand operations and is examining hazard reductions from micro-meteorites and space radiation that may result from the hard suit.

Clearly, the advantage of the 8 psi suit is its need to be operationally flexible in the 15 psi Space Station cabin atmosphere. Pre-breathing for low pressure suits in the shuttle program is minimized by a reduction of cabin atmosphere to 10 psi approximately a day in advance of the EVA. This has the disadvantage requiring the shuttle cabin to be operated at a higher percentage of oxygen (30%).

We could reduce the overall flammability hazard of the Space Station by lowering the percentage of oxygen content. At standard conditions of 1 atmosphere, the oxygen content is 21% of the total atmospheric pressure. In a 16% oxygen environment most burning self-extinguishes. This has been verified by tests conducted and represents the partial pressure of oxygen at an altitude of about 7500 feet, the lowest acceptable oxygen limit to man. A nominal value of 18% offers significant improvements in flammability reduction while offering a reasonable operational atmosphere equivalent to 4000 feet. It should be noted that the biomedical science user community has expressed a strong desire for the 21% oxygen atmosphere.

There is a concern that too much reliance is being placed upon EVA as part of the Space Station's design and assembly. One of the goals of the Critical Evaluation Task Force (CETF) held at Langley during August-September 1986, chaired by Ray Hook, was to evaluate the current baseline to determine whether design changes could be made to reduce the substantial EVA requirements. The task force has reported their findings to me which have resulted in some reduction of EVA. Extensive EVA, however, will remain a hallmark of the Space Station era.

Economics, safety, operational flexibility, and operational ease are strong considerations in the selection of a suit. The new high pressure suit undertaking comprises a major departure from our EVA operational data base at 4.3 psi. Suit development must be competently performed; otherwise, flight suit cost overruns could become enormous and could account for a significant portion of the Space Station budget. At the present time, we are still looking at options and alternatives for new designs. We have demonstrated operations at higher pressures, but the suit must be made more comfortable to be crew compatible. In FY'86 approximately $650K was spent on the new design. The program option is to maintain the present design, which is now certified for 21 hours, and recertify it to 40 hours of useful life as now planned, with pressure environmental restrictions on the pre-EVA activities. Obviously, any such restrictions would result in adverse effects upon Space Station operations in terms of both prebreathing and reduced number of EVA's. We are at the prototype stage of development, and I will review suit progress before a final commitment is authorized. The ASAP's evaluations would be welcome, particularly any thoughts which you may have regarding the safer pressure level.

Response:

The post Skylab era life sciences program has been approached managerially as a level of effort activity. We are taking steps to provide long term strategic planning to accomplish ASAP objectives. Over the past two years consolidation of the life sciences community has been implemented through the integration of the science planning conducted by the Space Biology and Medicine and Planetary Biology with Chemical Evolution Subcommittees of the Space Science Board, National Academy of Sciences. Also, an ongoing effort has been mounted by the NASA Advisory Council through its Life Sciences Advisory Committee to coordinate these scientific objectives into a cohesive activity. In addition, the NASA Advisory Council has chartered a special strategic program planning task force under the Chairmanship of Dr. Frederick Robbins to formulate a long range strategy for the life sciences programs for NASA. This also includes considerations of the cooperation among national agencies, universities, and international partners either now involved or else those interested in participating in space biomedical and biological research. I am anticipating that all these activities should culminate in organizing the NASA life sciences efforts into a cohesive program, responsive to NASA's long term goals by setting forth research priorities and supporting missions scenarios which will enable us to proceed with a timely program necessary to assure safe and medically sound human exploration of space.

2. "D. Space Station"

ASAP Recommendations:

"NASA should re-examine the resources required to conduct the many facets of the Space Station integration effort to ensure that the organization and human resources are sufficient to properly fill this role, now and in the future."

Other ASAP References to Space Station Resources and Organization:

1. Executive Summary, "Space Station," Page 4.

   "The panel foresees management/organizational concepts and arrangements, consistent funding support, and judicious funding allocation as being the key factors in successfully achieving the President's objectives for the Space Station Program."

2. Fact-finding Results of Calendar Year 1985.

   a. Page 57. "a. The Space Station organizational structure is quite complex with roles and missions and responsibilities difficult to discern at times. There is and will be occasional frustration in coping with the myriad of management prejudices and opinions that exist."

   b. Page 58. "b. There is some question as to whether NASA is adequately qualified to handle the complete integration of Phases C and D -- the hardware and software development."

   c. Page 58. "Meeting the Space Station Program objectives within a stringent budget requires early, quick, definitive action on the part of program management at all levels with emphasis on assuring that system engineering and integration organizations have the responsibilities and authority as reflected in the organizational structure."

NASA Response:

I concur with the Panel's observations regarding organization and funding. As recommended by the Panel, NASA has re-examined the resources required to conduct the many facets of the Space Station integration effort to ensure that the organization and human resources are sufficient to properly fill this role, now and in the future. The Space Station system engineering and integration function, previously performed by the Level B personnel at the Johnson Space Center (JSC), will be realigned for the next phase of Space Station development (Phase C/D) by realigning the system engineering and the system integration tasks. While we are considering retaining the system integration function in Houston (responsible to a program director located in the Washington, DC area), system engineering and analysis will become the responsibility of a new organization located in the Washington DC area. It is planned that this new organization will be assisted by a system engineering and analysis support contractor. The Space Station systems integration job will be further clarified through realignments in the content of the work packages managed by the NASA centers. These work package adjustments are intended to consolidate design and integration responsibility for all the various subsystems of a Space Station element (for example, the habitable module) under a single element manager. The realignments outlined will also clarify subsystem management accountability and design sensitivities for continuing alternative assessments.

I, too, have concerns regarding the budget. If an "anytime return to earth" capability (escape as compared to safe haven) is provided, those associated costs could consume a large portion of the program funds. Prior to the Challenger accident we had baselined safe haven, but that has been reviewed by the Engineering and Operations Safety Panel with the recommendation to the program manager to provide an escape capability. Furthermore, there are new demands and requirements which are being placed upon EVA. A new, high pressure suit development program could consume a significant portion of the development budget. A new power system to increase the power capability over past programs must be developed. These represent some of the budget threats, and of course, there are many others.

The basic configuration has been under review. A Critical Evaluation Task Force (CETF) headed by Ray Hook of Langley, was established in August to critically evaluate the current baseline configuration for optional designs and assembly sequences. This was evaluated in conjunction with the loss of the Challenger and bringing orbiter 105 on-line, and fitting the Space Station into the revised mission model. The task force focused on four areas: transportation limitations, the substantial EVA requirements, adequacy of the safe haven concept, and adequacy of early scientific utilization. For that purpose there were seven teams established: Transportation, EVA, resource assessment, configuration, users, cost, and safety. This activity was completed in mid-September, at which time I was briefed on the task force findings. As a result, greater reliance will be placed upon robotics to relieve the EVA load.

ASAP Recommendations:

"NASA should determine possible means to alleviate the payload bay interface environment and design requirements (vibration, accelerations, loads) which drive some of the Space Station element and 'user' designs."

Other ASAP References to Environmental Requirements:

Fact-finding Results of Calendar Year 1985.

Page 58. "c. . . . it may be worth the effort to alleviate the ascent environment requirements which drive much of the design for the Space Station equipment and 'user' hardware."

NASA Response:

NASA is well aware of the stringent design requirements placed on the Shuttle payloads for aerodynamic flight hardening of STS equipment for the ascent and entry phases. The Space Station operational environment is relatively benign by comparison. These facts are being taken into account in design of the Space Station hardware. However, since the STS is our only means of transportation to and from orbit, the Space Station Program will necessarily design for the ascent and entry environments.

ASAP Recommendations:

"NASA should establish a small team composed of current and retired NASA/contractor persons who have first-hand knowledge of the early activities (1972-1976) on the Space Shuttle program. The team should define the 'lessons' that can be 'learned' in both management and technical areas, including the real possibility of using today's technology to meet Space Station needs."

Other ASAP References to Lessons Learned/Technology:

1. Executive Summary. Space Station. Page 5. "The technologies needed to produce and deploy the Space Station are essentially in-hand (relatively little 'new technology' is required compared to the STS Program)."

2. Fact-finding Results of Calendar Year 1985

a. Page 58. "d. Since there are many similarities between the STS and Space Station programs, looking into the 'lessons learned' relating to the early days of the Shuttle might better define Space Station actions to preclude missteps."

NASA Response:

NASA agrees with the Panel's recommendation to establish a small team to define the "lessons" that can be "learned" from early Space Shuttle activities and that could be applied to Space Station needs. A team of individuals who have first hand knowledge of early space shuttle activities and who have remained current in today's technology, will be assembled.

NASA feels that the present technology base needs to be expanded to meet the demanding challenges set forth for the Space Station Program by the President and by Congress. New technology thrusts have been initiated by NASA to anticipate the final requirements to be established for the initial orbital capability (IOC) station. In all, 14 disciplines are defined in the Space Station Advanced Development Program. Personnel in each area have been asked to develop specific hardware or software products that contribute to a better understanding of which high-leverage technologies will be able to meet the technical, cost, and schedule constraints associated with their inclusion in the development phase.

For example, the anticipated high power demand at IOC and beyond compels NASA to develop solar-dynamic technology for more efficient power generation. The presidential directive for a permanently manned presence in space demands new technology in environmental control and life support systems (ECLSS) and in extravehicular activities (EVA), such as a space-based suit. The Congressional mandate to NASA to use the Space Station Program to advance the field of automation and robotics in space requires that new technology be devised and developed. The growth and evolution goals set for the Space Station Program dictate new developments in all fields of spacecraft systems, including structures, thermal control, materials, power transfer, and fluid management.

3. "Space Junk", Executive Summary, page 5:

ASAP Comment:

"Efforts to resolve this issue internationally must be intensified before it moves from the concern to the problem condition. Any solution must consider not only the large trackable units but the small debris that represents an unavoidable collision hazard. The Panel would urge NASA through appropriate channels to establish an international consideration of this issue before it becomes a critical problem."

NASA Response:

1. The Panel's observation regarding space debris is proper. Where measured, the hazard from small man-made debris (less than one centimeter) is either greater than or comparable to, depending upon particle size, the hazard created by the natural debris environment. For particle sizes larger than one centimeter, the hazard from the man-made debris, to the extent to which we have been able to define it, is an order of magnitude greater than the natural environment. A safety problem clearly exists which must be resolved either through preventive design measures such as shields, also a costly item, or by hazard avoidance through the minimization of debris generation. The hazard minimization route is normally preferred, and the most effective technique would be through international cooperative efforts as the Panel suggests. Hazard detection means also constitute a potential part of the safety activity which requires further examination.

2. NASA is expediting work in this area. There are significant activities underway to address both the policy issues and the technical issues.

3. Prior to the establishment of or participation in any international forum, a U.S. policy should first be established. In addition to NASA, other federal organizations are involved, including the Air Force, Strategic Defense Initiative Organization Office (SDIO), Federal Communications Commission (FCC), National Oceanic and Atmospheric Administration (NOAA), Department of Transportation (DOT), International Telecommunication Union (ITU), and National Telecommunications and Information Administration (NTIA). We are working closely with the SDIO who has concerns about the problem. This is a critical subject which involves the SDI

programs and cost implications to NASA programs to implement.

4. Preceding any establishment of a national policy must be the establishment of a NASA policy. The Headquarters Office of Space Flight is presently the NASA organization focusing on space debris. They are working in conjunction with the Safety, Reliability, Quality Assurance, and Maintainability Office which has policy and standards responsibilities. An Orbital Debris Working Group (ODWG), chaired by Lee Tilton, Code MT, has been established with membership from the Headquarters program offices, the SRQM Office, and the International Affairs Office. Frequent meetings are being held to prepare an integrated technical plan and to develop a NASA policy position. JSC has the lead role in preparation of the technical plan. The plan and the policy position are scheduled for completion in January 1987 and will be followed by a presentation to senior management.

5. When the NASA policy position is in place, we anticipate increased efforts with the aforementioned agencies. Some activities have already commenced. NASA and the State Department's Bureau of Advanced Technology have held discussions regarding the international efforts. They have transmitted a paper entitled "Space Debris: A Policy Discussion Paper" for our critique. We would look to the State Department to take the lead in the establishment of an international forum. Mr. Don Kessler, JSC, has delivered papers to COSPAR, an organization providing an international technical, rather than governmental, forum. We have been working with the Air Force, who is examining sensors and warning devices as well as debris bumpers. NASA funds are being expended at the level of approximately one million dollars per year. The Air Force has also committed additional funds. A memorandum to define areas of cooperation between the two organizations is being discussed.

6. NASA has already taken some steps to ensure that space debris generated in orbital operations is minimized. For example, stages in orbit are vented rather than allowing pressure build-up to tank failure. The effects of debris on the Space Station operation and design are being studied under the direction of a Configuration and Analysis Panel, chaired by Dr. George Strouhal, JSC. This panel has a Space Station Natural Environment Design Criteria Working Group chaired by Dr. George Fichtl, Chief of the Atmospheric Science Division of MSFC. The

"Natural Environment Design Criteria Definitions" has been baselined to JSC 30000 as JSC 30425. It includes the meteoroid and debris environments.

7. The Space Station Program is baselining meteoroid design criteria and is being worked under CR number BB 000123. The Program Definition Requirements Document, section 3, is being updated per that change request. The goal presently proposed is 0.97 probability for "no penetration" of the habitable module element over a 10-year lifetime.

8. The Air Force Scientific Advisory Board has formed an ad hoc committee on space debris, chaired by Dr. Carl Bostrom of Johns Hopkins University. His committee is studying all aspects of the problem and is in the process of preparing a report on their activity. They appear to be concentrating on protection technology and are concerned with definition of the debris environment. The ground based radar systems are limited to 10 centimeters. A Shuttle flight experiment has been proposed by JSC to further refine the debris environment.

9. Space Debris is of growing concern also to astronomers. Dr. Arthur Hoag, Director of the Lowell Observatory, published a letter in the September 1986 issue of Sky & Telescope magazine which expressed the concerns exhibited by the science community. The article notes that the debris increased from 5,600 objects (4 inches and up) in 1985 to 5,900 in 1986 over an 8-month period, a sizeable increase in a short period. Dr. Michael M. Shara and Dr. Mark D. Johnston wrote an article entitled "Artificial Earth Satellites Crossing the Fields of View of, and Colliding with, Orbiting Space Telescopes," for Publications of the Astronomical Society of the Pacific, August 1986, page 814. The authors concluded that debris will cross the Hubble Space Telescope's (HST) field of view with "distressingly high brightness and frequencies." The Faint Objective Camera and the Wide-Field Planetary Camera are science instruments which will be affected. They calculated a 1% probability of the HST being "destroyed" by a fragment greater than 10 centimeters during a 17-year mission. The authors point out that even greater susceptibilities exist for future space telescopes which are anticipated to have larger apertures and cross sections. There is interest by the scientific community in participating in the preparation of policy.

10. Again, we would like to assure the Panel that NASA recognizes both the seriousness and the criticality of the "space junk" issue. The NASA policy position and technical plan will be forwarded to the Panel under separate cover as soon as they are finalized.

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

DRAFT

Mr. Joseph Sutter
Chairman
Aerospace Safety Advisory Panel
9311 Fauntleroy Way
Seattle, WA 98131

Dear Joe:

The third and the final NASA response to the ASAP's 1985 Annual Report is provided in the enclosure. This response pertains to recommendations and issues regarding the Space Transportation System (STS). It is grouped into the following five parts: Orbiter, propulsion, shuttle operations, payload interface standardization, and Shuttle Centaur.

After considerable technical and managerial evaluations, as a result of the tragic Challenger accident, I am confident that NASA is taking appropriate measures to return the STS to a safe flight status. On July 14, 1986, I reported to President Reagan on NASA's implementation of each of the Presidential Commission's recommendations. That process is now under way. I would welcome any thoughts and recommendations which the Panel may have regarding the program as you undertake your reviews and deliberations.

Sincerely,

James C. Fletcher
Administrator

Enclosure

FINAL RESPONSE TO 1985 ASAP REPORT

I. ORBITER

A. Orbiter Structural Life Certification

1. ASAP Recommendations: "An abbreviated conservative analysis should be documented to fulfill the certification program." (p. 7)

   NASA Response: The fracture/fatigue analysis for LI 36, the wing/mod fuselage/aft fuselage structure has been deferred to FY 1988 due to budget constraints in FY 1986. NASA plans to conduct and document the required analysis in FY 1988. This will complete the structural article life certification.

2. Fact-Finding Results Concerning Structural Certification: "Orbiter Structural Adequacy and Certification Program." (p. 33)

   a. ASAP Comment: "The last remaining wing root fatigue and fracture analysis has been started, but will not be completed due to lack of funding at this time. ... However, in order to have a complete structural life certification program, a short-cut analysis should be made and documented." (pp. 33, 34)

      NASA Response: Fatigue life assessment and certification will be completed in 1988.

   b. ASAP Comment: "However, it should be noted that a loads calibration program will not be conducted on the Orbiter wing, but may be required if the flight results are questionable." (p. 35)

      NASA Response: NASA plans to conduct a loads calibration program on the OV-102 wing prior to its next flight.

   c. ASAP Comment: "Other structural components, e.g., the crew module, will not be well documented." (p. 35)

      NASA Response: The crew module is contained internally within the Orbiter forward fuselage and as such is protected by the forward fuselage structure. Accordingly, primary emphasis has been placed on structural certification and documentation of the forward fuselage assembly.

d. ASAP Comment: "These modifications should be the end of any required wing mods." (p. 36)

NASA Response: Unless other mods are found to be required as a result of 6.0 loads/stress analysis or instrumented OV-102 flight test, no further changes are planned.

B. Orbiter Structural Adequacy: "ASKA 6" Loads/Stress Cycle Program

ASAP Recommendations: "The Panel agrees with the arbitrary force approach taken at this time. However, the primary load path structure and thermal protection system analysis should be a stand alone report, fully documented and referenced even if the September 30, 1987, end date slips. In addition, it is felt that an operating restriction report and strength summary (external loads and vehicle stress) report for each Orbiter should be prepared in order to have quick access to information for making future decisions." (p. 7)

NASA Response: Stand alone reports will be issued at the conclusion of the 6.0 Loads/Stress cycle. Reports will be issued for the primary structure, the tile system and the leading edge structural system.

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

The Orbiter loads are summarized in Rockwell Document SD 73-SH-0069-2D, "Structural Design Loads Data Book, Volume 2-Orbiter Structural Loads." This document will be updated to reflect the 6.0 Loads/Stress cycle.

Post 6.0 loads/stress analyses activities include a task to provide a strength summary and operating restrictions report.

C. Redlines and Modifications

ASAP Recommendations: "In order to provide 85 percent launch probability redlines, the (wing) modifications should be made, even if slightly conservative, in some structural areas. Redlines on OV-103 and OV-104 should be specifically examined and changed as required." (p. 8)

NASA Response: Wing Mod Group Numbers 1, 2 and 3 will have been installed on each of the Orbiter vehicles as required prior to each vehicle's return to flight. The launch redlines will be revised as required for all vehicles.

D. Orbiter Avionics and Software

1. ASAP Recommendations: "NASA must monitor this most carefully since applications software can be very expensive to change and retest. Discipline with regard to the new computer codes may be more difficult to implement than management thinks ... it was tried on the Apollo program with little or no success. The wisdom of procuring one new computer each year may well lead to the same problem with spares found throughout the LRU program, and deserves additional attention, especially with increasing flight rate and the use of "new" computers." (p. 8)

   NASA Response: All changes to flight software will have to be approved by a Level II Board (Orbiter Avionics Software Control Board).

2. Fact-Finding Results:

   a. Mass Memory Units

      ASAP Comment: "This load can be, theoretically, accomplished from the ground but the process is slow and has never actually been tried. For a mission abort, the MMU must be used to load the entry program and is, therefore, a critical flight-safety item." (p. 37) ... "The Panel supports the upgrade. However, the cost and schedule (18 months to two years) require NASA's continuing attention." (p. 37)

      NASA Response: The mass memory unit upgrade program was put on an indefinite hold due to budget constraints.

   b. Central Processor/Input Output Units

      ASAP Comment: "Although IBM would, of course, continue to provide logistic support for the old shuttle computers by keeping a special line open, NASA would be the only customer and the cost to NASA could be unreasonable." (p. 37) ... The panel "questions the adequacy of this decision (to buy 24 flight and 6 non-flight computers) since the lack of spares has always been a significant problem." (p. 39)

      NASA Response: NASA is buying 26 flight general purpose computers (5 GPC's each for 4

Orbiters, and 6 spare GPC's). Additional spares will be ordered when sufficient data is available to predict attrition rate. The procurement of old GPC's was cancelled when the upgraded GPC was approved. There are adequate spare old GPC's in the present inventory.

c. Inertial Measurement Units

ASAP Comment: "The new instruments are lighter -- 120 pounds versus 175 pounds -- and they use less power." (p. 39)

NASA Response: The new IMU's will use more power than the present units.

E. Brakes and Nose-wheel Steering

1. ASAP Recommendations: "Standard use of nose-wheel steering is recommended, regardless of the type of brakes. The system performance should also be analyzed to permit increasing nose-wheel steering authority, as much as practicable, in order to maximize crosswind landing capability. The carbon brake design should be pursued as quickly as possible to replace current materials. The resulting configuration should provide manifold improvement in Orbiter landing ground roll control and stopping reliability. Further, the Panel is still hopeful that NASA will seek practical means of reducing Orbiter landing speed." (p. 9)

NASA Response: Standard use of nose-wheel steering has been adopted and demonstrated on landing at Edwards AFB. It is estimated that the flight qualified carbon brakes will be available by the third quarter of CY 1988. The design requirement for the carbon brakes is 82 million ft-lbs capability versus the 55.5 million ft-lbs capability for the existing beryllium brakes. We have examined means to lower the Orbiter landing speed. However, the modifications required to obtain significant reductions in speed would be major in nature and are not considered to be practical at this stage of the program.

2. Fact-Finding Results Concerning Brakes and Nose-wheel Steering

a. ASAP Comment: "However, 9 degrees maximum may not be enough. In the usual case, crosswinds are never steady in speed or direction ... with these considerations it would seem that the maximum nose wheel steering angle ought to be increased to 15-20 degrees to deal with high crosswinds, blown tires, inadvertent departure from the hard-surface runway, or a case where drift or skid exceeds the angular limits of the nose wheel. Will the nose wheel steering system allow for free-castoring if it goes to a hardover position, that is, a fail-safe, fail-operational condition?" (p. 40)

NASA Response: The Orbiter crosswind capability has been evaluated in simulations, and the nine degree limit has been found adequate to 20 knots with one blown tire. The system recovers in the castor mode from a hard over condition.

b. ASAP Comment: "There is concern by the STS management about the availability of resources to support the development of the carbon brakes." (p. 41)

NASA Response: Since the original concern, adquate resources (approximately $9 million) have been budgeted to fund development of the carbon brakes.

F. "(4) Landing Handling Qualities"

ASAP Comment: " ... it would behoove NASA to undertake such a research program (i.e. control augmentation devices or surfaces) with the view of furnishing timely information for future designs of the shuttle type, including possible flight tests of a research-type vehicle at either Ames or Langley Research Centers." (p. 41)

NASA Response: NASA has been funding research into advanced vehicles at the rate of approximately $1M per year. This activity is being conducted primarily at the Langley Research Center's Space Systems Division. The technical staff has published papers on the results of their studies.[1]

[1] Powell and Freeman, "Application of a Tip-Fin Controller to the Shuttle Orbiter for Improved yaw Control," Journal of Guidance, July-August 1982.

Powell and Freeman, "Aerodynamic Control of the Space Shuttle Orbiter with Tip-Fin Controllers," Journal of Spacecraft, Sept.-Oct. 1985.

Wilhite, Powell, Naftel, Phillips, "The Future Space Transportation Systems (FSTS) Study, 'Booster and Orbiter Configurations'," Astronautics and Aeronautics, June 1983.

NASA is currently involved with high-level trade studies of fundamental approaches to future space transportation concepts. More detailed studies of performance, payload capabilities, costs, etc. for the future concepts are to be undertaken. The hypersonic and landing characteristics are clearly two parameters of paramount importance to us, and these will be examined in great depth as the study activity progresses.

G. "(5) Automation"

ASAP Comment: "Automated landings, while still in the program, have not been demonstrated and are not in favor with the current pilot astronauts. They question the system's reliability and prefer a "hands-on" landing capability. However, it would appear that since landings at KSC are deemed mandatory to reduce the turnaround times between missions, the use of their automated system might well be needed to assure meeting the flights-per-year goal. An incongruity appears here in that the launch and ascent portion of the mission is already fully automated and been found to be extremely reliable throughout. The question that arises is: if the flight system for ascent is relied upon, then why not the flight systems for landing?" (pp. 41, 42)

NASA Response: The automated landing system for the Orbiter is available if needed but has not been demonstrated in flight as the panel observes. I believe, however, that a dependence on this system in order to increase the flight rate or to reduce the turnaround time should not be considered verified for routine operational use. The Shuttle Training Aircraft's (STA) activities have not demonstrated either consistent nor acceptable touchdown parameters while operating in the automatic mode. It has revealed, however, a limitation of the landing software to compensate for the ever changing and unpredictable environmental conditions, such as wind shears, high winds, etc., through which the Orbiter must fly. STA training with flight crews has shown that the astronaut pilot can make consistently better touchdowns using the "hands-on" operational mode. The added training time requirements for automatic landings would significantly increase the crew's training time because flight rules require that the crew be able to take over from the automatic mode after unplanned upsets, systems failures, or loss of control. Some of these take-over conditions can be verified in the Shuttle Mission Simulator (SMS), some in the STA; others, however, cannot be accurately demonstrated nor practiced. Our crews in training routinely fly "hands-on" approaches to touch down at facilities and runways without a microwave landing system (MLS). The MLS is required for an automatic landing. Any additional landing aid improves the crew's performance and confidence. We believe, based on NASA's success rate, our desire to maximize crew and training team capability, and to minimize the risk that we should not consider automatic landings as a factor to increase flight rate or turnaround capability.

H. Fuel Cells

Fact-Finding Results

ASAP Comment: "The bank of cells is fully redundant in a come-home emergency sense, but the mission power loads are high enough that there is not complete redundancy in a mission-power sense. This subject is worthy of review to assure the design of these accessories is, in fact, conservative." (p. 33)

NASA Response: The Fuel Cell Powerplant (FCP) improvement introduced during the flight program increased the number of cells from 64 to 96 in each of the three units. The 50% increase can provide more power for critical functions in the event of one or two failures. A power fault tolerance study now under way will determine the new margins for both ascent and entry. In addition, a new upgrade to be ready for flight resumption will improve reliability and safety. The changes include the elimination of end-cell heaters, which had numerous electrical components and the risk of a fail-on condition, and an expanded diagnostic capability to speed failure detection and isolation.

II. PROPULSION

A. Space Shuttle Main Engines (SSME)

1. ASAP Recommendations: "The recertification approach selected by NASA permits different parts of the engine to be 'certified' for different flight times. However, since most of the Phase II turbopump component improvements really only address degradation rates of critical components under nominal mission environments rather than increased stress level margins (the exceptions are the decreased High Pressure Fuel Turbine discharge temperatures -- 100^{o} and a 7000 RPM improvement in synchronous whirl margin on the oxidizer turbopump), the Panel recommends that the engine be operated at power levels above 104% of Rated Power Level (RPL) only when mandatory. Also, when engine operation above 104% is necessary, the power level selected be only the value required for the particular mission and not taken all the way to 109% except when mandatory.

"The Phase II development and demonstration program should provide a data base for the modified turbopumps which can be used to estimate new Mean-Time-Before-Replacement criteria for the turbo-machinery. The hardware necessary to support this replacement rate should be made available in order to maintain the engine's new certification status and protect flight safety margins.

"We further recommend that the "precursor" (future) program improvements be supported at a level such that they can in fact be incorporated as soon as possible into the flight engines. In the long run, such expenditures will be cost effective as they result in more reliable flight engines with lower maintenance costs and a higher availability factor." (p. 11)

NASA Response: A power level of 104% RPL has been baselined (not to be exceeded except in emergency) by program direction.

New MTBR criteria have been established, and hardware requirements are covered by the proposed FY 1988 budget.

The precursor program will have to be delayed until the design and certification of critical items required for the first flight are accomplished. At that time (mid to-late 1988), NASA hopes to accomplish the testing of the precursor candidates.

2. Fact-Finding Results: "b. Space Shuttle Main Engine"

a. ASAP Comment: "Funding constraints in 1984, and continuing in 1985 and for the foreseeable future, have revised the planned program. . . . The Phase III part of the original program was eliminated and replaced by several other program elements. One of these, labeled Phase II-Plus, will develop and certify a new hot-gas manifold structure." (p. 42)

NASA Response: The program has been fully integrated and the 2-duct hot gas manifold (2+ program) will be certified along with the alternate high pressure turbopump in the early 1990's.

b. ASAP Comment: "Beyond these defined but limited tasks to improve known low-margin areas of the existing engine design, there is a new product improvement activity getting under way." (p. 43)

NASA Response: The alternate turbopump greatly improves the safety margin of the turbopump. This is achieved in part by increasing the margin of key components (heavier shaft). Use of new materials (single crystal turbine blades), and incorporation of instrumentation to provide data on turbopump health status.

c. ASAP Comment: ". . . component life limitations still exist in these areas and will continue to present replacement problems. Therefore, engine use at 109% of rated thrust should still be tightly constrained." (p. 44)

NASA Response: The 109% of rated power level capability is planned for use in Shuttle flights launched from the Vandenberg AFB site when it is reactivated. The 109% is required for early Air Force missions and such flights are not considered "routine." Until then 109% power level will be tightly constrained.

d. ASAP Comment: "However, the certification ground rules which permit replacements of various components such as turbopumps or blades, etc., during test series result in a somewhat questionable data base regarding true engine 'configuration' operating margins and valid Mean-Time-Between-Replacement values." (pp. 44, 45)

NASA Response: The quality of the pump design has created the program requirement to modify certification ground rules such that replacement of components is permissible prior to completion of the engine's rated life. This has been contrary to NASA's desires for a "clean" certification program, and consequently we approved in August 1986 the alternate pump program to provide a new, longer life pump with much higher safety margins. The desirable goal would be to perform limit testing to show margin, and this is under consideration. The philosophy, which has been adopted by the program, is to test for a given number of cycles and replace the flight motors after half of those cycles have been expended. That testing has revealed design deficiencies, and hence provision has been made for the procurement of additional pumps needed to maintain a safe operating factor on the low lifetime hardware. The same test margin for life deficient components is used as for the engine as a system. Hence, the impact to NASA is one of costs, through frequent component replacements, rather than one of safety.

e. ASAP Comment: "However, unless the new hardware is made available to support a more conservative Mean-Time-Before-Replacement schedule on the critical components currently showing wide scatter in lifetime, the "cannibalization" and "parts mixing" which now go on will seriously limit the value and effectiveness of this facility." (p. 45)

NASA Response: This was accomplished in the 1986-2 POP cycle.

B. Solid Rocket Boosters

1. ASAP Recommendations: "The Solid Rocket Booster holddown bolt calibration tests should be carefully examined at this time to aid in obtaining meaningful final test results. If the calibrated test results differ from that used in the Cycle-III analysis then the pre-launch and lift-off loads for the External Tank and Solid Rocket Booster will be incorrect. This could cause serious problems in meeting launch requirements." (p. 13)

NASA Response: The following provides a clarification of issues raised in the recommendations above:

a. The holddown bolts are load calibrated off-site before being installed in the holddown post. No problem exists with these strain gauges or with loads data accuracy of the holddown bolt. However, accurate bolt loads do not provide sufficient data for assessing SRB aft skirt and aft SRM segment loads experienced during SSME thrust buildup and pad abort; neither of the post loads provides data necessary to determine SRB/holddown post load interface initial conditions at the time of SRB pad release. These data are obtained from strain gauges located on the launch pad holddown posts; to date, calibration attempts have not yielded the desired accuracy.

b. The purpose of calibrating the holddown post strain gauges is to obtain accurate axial and lateral measured loads data for the transient events of SSME thrust buildup through vehicle release and on-pad shutdown to compare with design loads criteria. The calibration results are not used in the analyses in developing design loads or verification loads criteria.

As mentioned in item (a), attempts have been made to calibrate the holddown posts with sufficient accuracy to assess critical loads but without success. The posts were calibrated at the VAFB launch site in March 1985 by applying uniaxial loads to calibrate the strain gauges. Simultaneous lateral and axial loads were then applied to verify that the gauges would provide accurate data for loads simulating SSME thrust buildup. The gauges did not provide the desired accuracy. Subsequent to the VAFB calibration tests, a single post calibration test was conducted at KSC in the Launch Equipment Test Facility (LETF) with strains installed at different locations on the post than in the VAFB tests. This test was also unsuccessful. To date the post calibration objective has not been satisfied; however, the holddown post (HDP) strain calibration technique will be developed at KSC and then applied at VAFB. The HDP model used in the cycle-III analysis will then be compared with the measured calibration data.

2. ASAP Recommendations: "Continued analysis and further studies have to be conducted in order to fully understand the failure mode. Additional studies should continue to evaluate membrane/transition layups and coupon specimens. Until the issue can be resolved with a high level of

confidence, the Panel believes the FWC SRB's should not be used for STS launch. The Panel would like to be kept informed of the analysis results and of these upcoming tests." (p. 13)

Additional ASAP Comments Regarding SRB Structural Integrity

ASAP Comment: "Executive Summary" -- The ASAP notes a particular concern in the 'Executive Summary' with structural strength of the Filament Wound Case (FWC) for the uncertainty of the Solid Rocket Boosters (SRB's). Tests and analyses to date leave considerable questions as to the strength margins of safety in the transition areas between case segments. Until the issue can be resolved with a high level of confidence, the Panel believes the FWC SRB's should not be used for STS launch (and certainly not for the first launch from VLS)." (p. 3)

NASA Response: Coupon tests of the FWC transition have been completed utilizing specimens from the failed STA-2A test article, segments from the static fired DM-6 and DM-7 motors and from tag end mirror image transition sections wound in conjunction with VLS-3 aft segments. The failure mode of the coupons was compared to the failure mode of the full scale article by inspection, with good correlation. Detailed analytical models were developed of the coupon and the full scale segment transition. From these analytical models, critical stresses which support the failure theory and strength criteria were identified and also correlated to the measured failure load of the STA-2A test article. It is agreed that certification of the FWC for flight cannot be completed until further full scale tests which verify the structural margin are completed. During the FWC 140% compressive structural load test to simulate loads at SSME ignition, the AFT skirt failed at about 130%. Methods to structurally load the FWC segments to 140% are being evaluated. A test to failure of a full scale segment is also planned for the first half of 1987.

3. Fact-Finding Results of CY 85

a. ASAP Comment: "The FWC STA-2 (Structural-Test Article) was tested for prelaunch loads and failed at 118.4% of limit load. The failure mode was not properly identified and is receiving further study." (p. 46)

NASA Response: Prior to the STA-2A test failure during the prelaunch load test, the failure mode that resulted was unknown. This was due to the lack of very detailed analytical models of the membrane to joint transition region of the case, which would have identified areas of high stress concentrations. As a result of the subsequent failure investigation, the necessary detailed analytical models were developed. Coupon tests of specimens of the transition region, cut from full scale segments were also conducted. With the good correlation between the analytical models and coupon test results, and correlation to the failed test article, the failure mode is believed to be now well understood, with failure theory and strength criteria established. Verification of this work is planned with further full scale tests.

b. ASAP Comment: "Filament wound case DM-7 firing showed that at about 80 seconds there was significant thrust oscillation. This requires further analysis..." (p. 47)

NASA Response: The cause and evaluation of the thrust oscillations observed during the DM-7 static firing has progressed but is not yet fully resolved. The oscillations, which were between 2.5 and 3 psi, are believed to have resulted from frequency coupling between an inhibitor located on the propellant face at the end of each motor segment and the case. Substantiation of this theory by analysis has not been completed due to the work load impact of the Challenger accident. The effect of this oscillation on vehicle loads was conducted and found to be enveloped by the allowance already incorporated for thrust oscillations. The value observed for DM-7, however, cannot be considered a 3 sigma value and additional static firing data is needed for further verification. Before FWC-SRM flight, at least two additional static firings will be accomplished which will allow determination of maximum values for thrust oscillation, and the effect upon flight loads can then be reassessed.

c. ASAP Comment: "A search is under way for an insulation replacement since the use of asbestos is no longer legal. This is a real concern..."

NASA Response: Activities to eliminate the use of asbestos in Shuttle SRM materials have been under way for more than two years by JPL and Morton Thiokol (MTI). JPL has selected and evaluated in 40-lb. test motors, non-asbestos containing insulating materials and will evaluate the most promising in 48" test motors within a few months. MTI is conducting a similar program and several coordination meetings between MSFC, JPL, and MTI have been held for data comparison and planning. Results from the 48" motor tests will identify those materials for in-depth processing and bonding assessments. The overall schedule and development/quality plan for the replacement of the internal insulation and other asbestos containing materials in the shuttle SRM is being updated and is available.

C. External Tank

Fact-Finding Results

ASAP Comment: "However, any reduction in design margins must be carefully studied and understood. The possibility of shell buckling must be kept in mind..." (p. 48)

NASA Response: The above statement is true in all respects. However, there is no structural redesign planned for the ET.

III. STS OPERATIONS

A. Flight Crew Training

ASAP Recommendations: "NASA must commit the funds in a timely manner to ensure an adequately-sized fleet of training aircraft to meet the flight crew training needs, without reduction or compromise to the Orbiter flight training syllabus." (p. 10)

NASA Response: NASA agrees with the recommendation. The successful completion of modifications to a Gulfstream II aircraft in July 1986 increased the Shuttle Training Aircraft (STA) fleet to a total of three. In addition, a spare STA wing has been purchased and is undergoing modifications for scheduled availability in FY 1989. The fleet of aircraft currently budgeted will be capable of meeting the flight crew training needs over the next few years in view of the manifest reduction expected due to the Challenger accident. Plans are being formulated to purchase and modify an additional aircraft that may be available in FY 1989.

B. Logistics and Launch Processing

1. ASAP Recommendations:

   a. "NASA management should monitor closely the effects of the recent reorganization at KSC to make sure that it has accelerated and simplified management of launch processing." (p. 14)

      NASA Response: We are continuing to observe and evaluate the SPC's performance and the ability to accomplish launch processing operations safely and efficiently.

   b. "NASA should examine the feasibility of developing data systems under management of the SPC, such as configuration management, that will centralize and augment KSC's operational launch capability." (p. 14)

      NASA Response: It is NASA's intent that the SPC should be involved with the data systems for implementing configuration management and other functions to optimize launch activities.

   c. "NASA should continue to give high priority to acquisition of spare parts and to upgrade the reliability (planned life) of hardware, especially items associated with the space shuttle main engine." (p. 15)

NASA Response: The POP 86-2 addressed this issue and funds an adequate supply of spares. The alternate turbopump program was awarded to Pratt & Whitney and will greatly improve the high pressure pump reliability because of increased margins in key components and the incorporation of instrumentation to provide data on turbopump health.

d. "NASA should explore whether better coordination could be achieved between those persons determining manifests for specific flights and those persons charged with launch processing. In some instances, the combination of payloads has exacerbated the launch processing sequence." (p. 15)

NASA Response: Planning and coordination are actively pursued at all NASA levels between manifesting persons and those charged with launch processing to optimize flows and at the same time satisfy customer relations.

e. "Facilities should be provided to minimize turnaround times of the Shuttle and Line Replaceable Units (LRUS).

- o Orbiter Maintenance and Refurbishment Facility (OMRF) building should be authorized.
- o LRU repair facilities should be provided at KSC for all units which can be properly and efficiently handled there." (p. 15)

NASA Response: An Orbiter Maintenance and Refurbishment Facility is currently under construction and is planned to be operational by late 1986 or early 1987. In addition an interim depot repair facility has been established offsite at KSC. This facility is operational and is currently certified to repair over 40% of the items identified for non OEM repairs (1460 items out of 3,457 total). The full up depot will be on line in 1991.

2. <u>Fact-Finding Results: "e. Launch Sites/Vehicle Processing/Logistics"</u>

a. "VAFB Launch Complex Development (VLS) Issues."

(1) ASAP Comment: "The Flight Readiness Firing (FRF) program will serve to resolve many remaining problems and add confidence in launch safety. Two major tasks still require resolution, namely, the system for ensuring safe burn-off of residual hydrogen in the SSME exhaust duct and the verification of actual launch mount loads on the pad, which are being pursued vigorously." (p. 49)

NASA Response: We are aware of the ASAP observation, and concur with the recommendations. During the approximate 2-year standdown resulting from 51-L, the Air Force will have the time to solve the SSME duct hydrogen burn-off problem and conduct the SRB special loads tests. This additional time will allow for more complete data reduction during test and for additional mods and tests required to assure that all problems are solved.

(2) ASAP Comment: "The Program organizational, staffing and personnel, planning, and training elements appear to be sound and providing the needed strengths to achieve program goals. The test program, including the FRF, appears thorough and one which will pay dividends in successful future launches. And, finally, the cooperative teamwork between the USAF and NASA at the VLS is highly evident and, the Panel believes, a great strength in the national space effort. There are two additional observations which the Panel would note: (1) the 7-day work week, success-oriented schedule, which carries certain risks; (2) over the long term of future launches at VLS, orderly success will depend, in large part, upon retention of a stable, experienced launch team. The Panel urges USAF consideration of a personnel assignment policy which will ensure that future capability." (p. 50)

NASA Response: This down time will also allow the Air Force to work other problems on a more leisure schedule than the success oriented 7 day/3 shifts workweek noted by the panel as a concern. We agree with the recommendation for the retention of a stable, experienced launch team. The NASA detailees are not permanent, and neither are the Air Force personnel. The government employees provide the data base and glue required to hold the contractor launch team together and assure a safe and successful launch operations process. We agree that the Air Force should review and address their personnel assignment policy as requested by the ASAP. They may decide to include more NASA involvement to ensure that safety concerns and issues are not overlooked in the future.

b. KSC Operations

(1) ASAP Comment: "Last year in its annual report the Panel noted that the Shuttle Processing Contractor (SPC) was struggling to handle the burden of work associated with each mission. Factors associated with these difficulties included: unplanned vehicle modifications, unexpected anomalies, shortage of spare parts, shortage of qualified technicians, heavy paperwork burden, planning and communication concerns, and some lack of hardware reliability. The past year has seen progress in resolving these problems but most of them are still present in some degree and will likely persist for the foreseeable future, thereby limiting the extent of "operational" status the STS is likely to achieve. Specifically:

"(a) SPC Performance. The SPC is improving its internal planning and operations through better communication within the SPC operation and with KSC and other NASA centers. Presence of SPC representatives at the centers has helped considerably. Workflow at the VAB and the pad seems under control. However, the Orbiter Processing Facility (OPF) capacity will have to be increased if the projected flight rate for 1987-1988 is to be achieved. Data systems to provide a common base of information around which to schedule the flow are still being developed, for example, all configuration management systems are outside the SPC's control and will remain so for the foreseeable future. Unplanned modifications now require only about 5% to 8% of the processing time, a considerable improvement; however, about 35% of the time is still devoted to responding to unplanned tests or change-outs resulting from flight concerns and anomalies." (p. 51)

NASA Response: SPC has made progress in improving Shuttle processing. NASA agrees that to accomplish higher flight rates, it is necessary to reduce work in the Orbiter Processing Facility. Emphasis has been made at all levels of NASA management that only essential tests, modifications and work should be performed from flight to flight. Unplanned modifications have been greatly reduced. Continued improvement in reliability of many elements of the Shuttle vehicle are necessary and being pursued in order to improve processing flow rates. Good progress to date with electronic "black box" maturity is demonstrated by the reduction from the 35% of processing formerly spent on unplanned tests and change-outs to currently about 20%.

(2) ASAP Comment: "(e) Flight rate. Given existing constraints -- hardware, spares, modifications, absence of data systems, manifesting difficulties -- the goal of 18 flights per year is not within reach at present. A more realistic goal is between 12 and 15 per year. The best composite time to date (best time at each facility, OPF, VAB, Pad) is 44 days. KSC hopes to reduce it to 35 days in the near term and, hopefully to 28 days eventually (goal). One fact is increasingly evident: sophisticated payloads result in long occupancy times in the OPF." (p. 52)

NASA Response: As a result of the 51-L accident, NASA is reviewing all resources with the goal of defining the date at which we can return to flight status and the rate at which we can fly in a reliable and safe manner. The concerns noted by the Panel are being addressed in this review.

IV. PAYLOAD INTERFACE STANDARDIZATION

ASAP Recommendations: "There will always be peculiar requirements for special payloads, but insofar as is feasible, there should be increasing effort to preparing and carrying payloads in a standardized fashion." (p. 16)

NASA Response: NASA agrees with the ASAP recommendation. The NSTS payload integration process provides a system to accommodate both complex and simple payloads. For example, two upper stage configurations have completed integration with the National Space Transportation System (NSTS). These are the PAM and IUS. Generic documentation has been generated for these upper stages, which the customer may use if his payload utilizes one of them. Because this documentation is already prepared, the customer has to provide only that information which is mission unique, thereby reducing the amount of time and effort required of the customer. These same measures will be incorporated for new upper stage configurations to facilitate the carrying of the greatest number of payloads in a standardized fashion.

V. SHUTTLE CENTAUR

ASAP Comment: "It is quite apparent that the problem of mating the successful Centaur (an unmanned design) with the manned Shuttle was underestimated by everyone. The extent of the changes to Centaur to be compatible with the redundancy and safety requirements of the manned Shuttle are such that new qualification and certification testing is required in many component and subsystem cases. This testing is occurring late in the program and may well be the most critical problem in meeting the schedule. The lateness, it turns out, is not so much a result of technical problems but rather of the initial decision to treat the Centaur as a payload, independent of the Shuttle. Much of the electronic hardware is late owing to problems with parts like the relays and in acquisition of hi-rel solid state devices (an endemic problem for small lot purchasers). This organizational posture inhibited or delayed the recognition of the magnitude of the system integration task posed by Shuttle-Centaur.

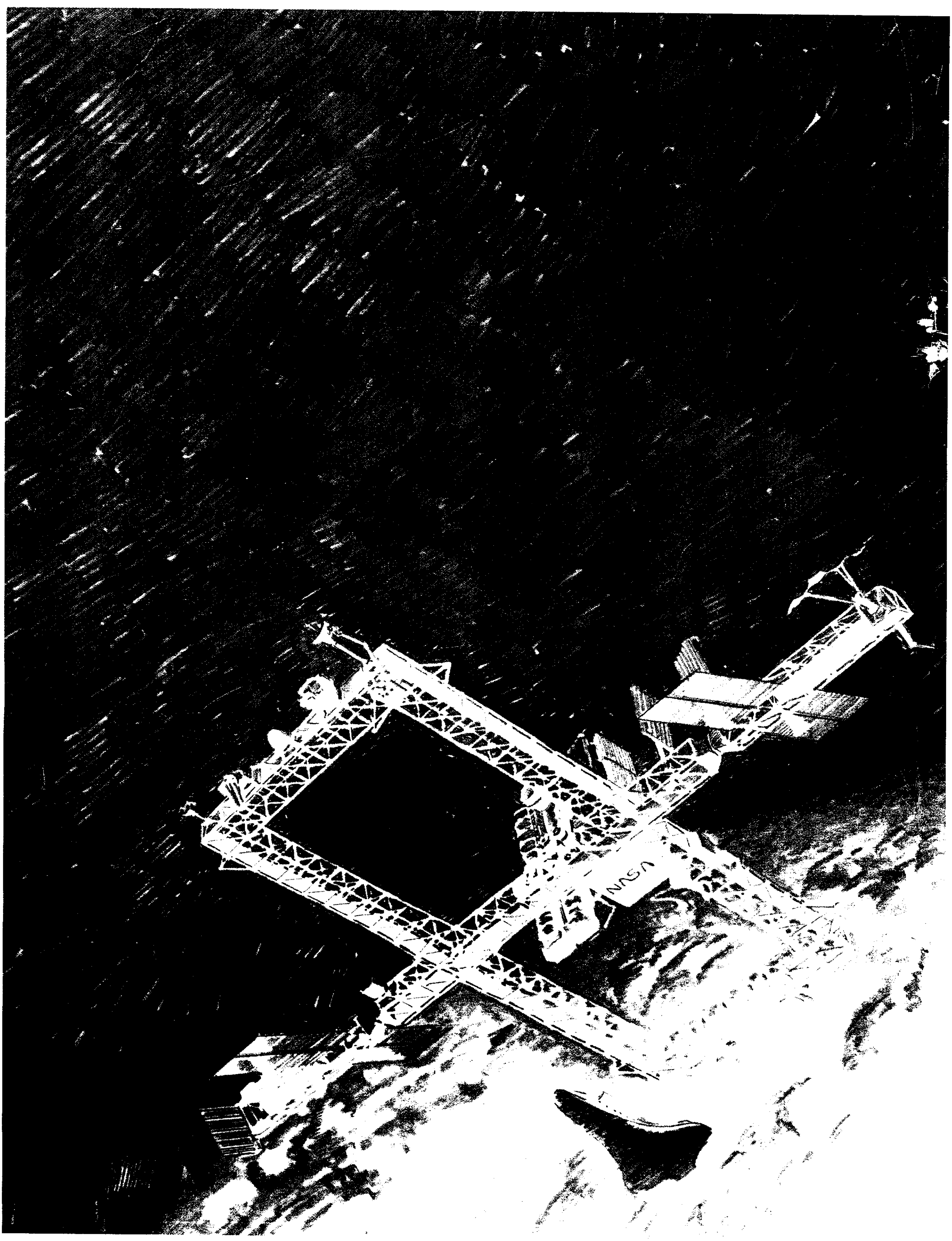
"The Panel has followed the technical progress of this program and while there are some current worries, they revolve more around the results of unfinished testing for certification rather than perceived real problems. Our concern really is: can the volume of outstanding work be done in time to meet the schedule? The program is aware of this and appropriate emphasis and the show stopper, if there is one, is the sheer magnitude of the work to be done and the lateness of component and system qualification and verification. This problem has been evidenced in previous reviews but should have subsided by now. It has not. Design changes are still being made, for instance some 20 changes in the ground launch system to shift its philosophy from fail safe to fail operational. This is a worthwhile goal and natural launch system evolution but should not burden the system -- if it does -- prior to Galileo and Ulysses deadlines.

"The system should realize that the old philosophy that technical perfection is more important than schedule with sufficient margin so that adequate technical performance can be obtained for fixed schedules. It is the difference between a development program and a transportation system. The case in point is that more than a few systems are to be verified or qualified as a result of the wet countdown on the pad. This simply does not allow any time for corrective measures should problems develop. Program management should prioritize the remaining work so that if necessary items essentially in the 'confirm for the record' class can be waived." (pp. 54-55)

NASA Response: Fully cognizant of the kinds of concerns expressed by the ASAP, I made the decision to terminate the Shuttle Centaur Program in June 1986. That was a very difficult decision to make, and it was only after a thorough review of all aspects of the program by all parties involved, including the Air Force, that the decision was made to cancel the program on the basis of overall safety considerations. The decision should not be interpreted, however, as total exclusion of the use of cryogenic stages as shuttle payloads on future flights.

A "Shuttle Centaur Alternative Trade Study" activity was initiated to examine the optional means of launching the critical planetary spacecraft: Magellan, Galileo, and Ulysses. Mr. Aller chaired an advisory group consisting of Dr. Rosen and Mr. Sade (Headquarters), Dr. Lyman (JPL), Mr. Baumann (GSFC), and Dr. Cook (DOD). This activity concluded with a presentation to me on November 4, 1986. As a consequence, NASA has baselined an IUS - STS launch capability for these payloads. Transportation of the IUS and other solid propellant motors has a proven safe track record aboard the STS.

James C. Fletcher
Administrator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