

along with retrieval of SRB's has been proven through the fifteen STS missions to date. However, one area of continuing interest is the impact of flight vehicle and ground equipment hardware and software changes (both generic and mission unique) and procedural changes upon the ground sites, including modifications to the launch constraints or so-called "red-and-blue lines." With regard to any of these the safety impacts continue to be analyzed covering such things as:

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

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

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

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

developmental aspects of the program are of continuing interest:

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

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

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

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

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

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

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

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

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

The SPC in its operations has uncovered some

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

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

One of the greatest impediments to rapid turnaround time at KSC - apparently second only to shortage of spares - is the continuing need for modifications. It is true that every modification requirement is most carefully scrutinized by various engineering committees but the cumulative effect of all of these, together with the poor-fit difficulties, is causing considerable distress at the launch site. This entire issue goes back to the question of major overhaul,

maintenance planning and the inevitable backlog of modifications will constitute a pacing element. Not much "on-line repair" is being accomplished at KSC which again points out the need for a more definitive maintenance program.

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

2. Space Shuttle Main Engines (SSME's)

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

At the end of 1983 a Three-Phase Program was undertaken at Rocketdyne to systematically address these issues. The Phase II and Phase III parts of the program

were well-planned to understand the operating limits and to analyze and correct the stressing areas. The basic goal of the program was to improve the operating limits for components showing less than 5000 seconds at 109%, but also in reality to provide improved margins at 104% for higher flight confidence and lower-cost maintenance.

The focused goals of Phase II were to:

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

- o Eliminate the turbine sheet metal cracks

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

- o Increase first stage blade life on HPFTP

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

- o Improve rotor stability on HPOTP to increase whirl margin

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

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

certain areas represent different and lower-stress operating regimes.

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

About mid-1984 the Phase III program was eliminated by NASA. It was replaced by a much restricted Phase II+ activity and a longer range technology oriented Advanced Development program. The very limited Phase II+ program does not address most of the items identified in the 1983 Phase III Plan. The only significant change planned for certification is the new hot-gas manifold (HGM), and that HGM will not be introduced into the fleet until about CY 1988. Other key elements of Phase III will be evaluated in a "Precursor" portion of the Advanced Technology program. The elements include single tube heat exchanger with no internal welds, a large throat diameter main combustion chamber and advanced design turbomachinery. Since the "Precursor" program is technology-oriented only and very funds-limited, it is clear it will not really permit timely introduction of the major changes in turbomachinery nor large-diameter Main Combustion Chamber necessary to provide the desired final operating margins at 109%. Although major

progress in operating life of components was achieved in the Phase II work, this really relates to replacement cycle-life and not to the environment reductions critical to increasing margins which were planned for Phase III. It is our judgement, therefore, that the SSME should continue to operate with the 104% limit to the greatest extent possible. This will assure that the gains in changeout time are maximized with the attendant cost savings, and that margins are satisfactory for flight reliability.

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

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

3. Space Shuttle Solid Rocket Boosters

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

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

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

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

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

4. Orbiter Structural Adequacy and Life Certification

The Orbiter OV-099 was statically tested for 32 load cases to approximately 1.2 times limit loads (ASKA 5.4 loads cycle). Approximately 33 fatigue/fracture/acoustics supplemental test articles have been completed successfully, except for one which will be completed shortly, in accordance with the certification plan. A scatter factor of

four was used in these fatigue and fracture tests. It was decided to delete two tests because of cost and negligible damage shown by analysis due to the fatigue spectra. For instance, tension stress in the lower wing skin is approximately 30,000 psi. The Orbiter is designed for 100 missions whereby a commercial transport is designed for 50,000 flights. The one article, "LI 31", outboard elevon/flapper door/wing portion of rear spar has been tested to 100 missions of acoustic fatigue as test WA-18. The mechanical fatigue and ultimate design load conditions have not been tested. The specimen is now in storage.

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

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

Orbiter Wing and Fuselage Modifications Status:

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

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

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

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

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

ASKA 6.0 Loads/Thermal/Stress Cycle:

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

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

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

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

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

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

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

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

TABLE 1

ORBITER WING & FUSELAGE MODIFICATIONS STATUS

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

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

(2) Wing cover, ribs & internal structure

LRSI = Low temperature reusable surface insulation

HRSI = high temperature reusable surface insulation

AFRSI = Advanced felt reusable surface insulation

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

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

As evidenced by the many and varied EVA operations during 1984 there appears to be no problem with the current methodology which includes the reduction in cabin pressure from 14.7 psia to 10.2 psia hours before donning the suits which are then pressurized to 4.3 psia (pure oxygen). The return is accomplished in the same manner. Space Adaptation Syndrome (SAS) still appears to be a problem for a majority of the crews and may even have affected, for some period, those doing EVA work. It is apparent that the crew training for EVA is thorough, and certainly covers the work to be done each time in meticulous detail, which provides for safety as well. The Extravehicular Mobility/Maneuvering Unit (EMU) or space suit, has instrumentation necessary to status EVA operations. There is some question in-house as to the value of additional instrumentation or enhancements that would allow EMU consumables resource status in order to assess new EVA task and procedures for optimization. Such implementation would require measurement of a few new EMU parameters and telemetry of these new parameters along with some currently measured parameter to a central recording and analysis point. These data could allow understanding of task and procedures design as they affect man's integration into the EVA workplace. Specific parameters to be telemetered include Liquid Cooled Garment inlet and outlet temperatures, O₂ bottle pressure, suit pressure, electro-cardiography, battery power remaining, limiting consumables and possibly others. Some can be obtained through derived parameters such as heart rate and LCG temperatures. We believe this instrumentation would allow

the accumulation of a much needed expanded empirical data base.

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

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

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

Langley Research Center conducted studies of the

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

7. KSC and VAFB Common Operations

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

While this would seem to be a straight forward scheduling job it is complicated by two facts. First, the DOD may be required by circumstances to ask for an unscheduled launch on short notice. Second, the Orbiters

are not identical from a structural load capability and certain loads may require certain Orbiters. The scheduling problem is not bad if one formally identified it and is aware of the limitations it may impose on the joint operations. A subsidiary but important point is that the launch crews have not trained at VAFB nor has the facility been exercised. The Panel has recommended that an FRF be conducted at VAFB prior to the first launch as a facility and crew certification. A bonus to such a test would be a partial insight into the "Twang" effect on the stack under the VAFB hold-down conditions.

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

8. Shuttle/Centaur

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

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

both of these tests design assumptions were verified.

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

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

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

9. Radioisotope Thermoelectric Generator (RTG)

The Panel is aware of issues associated with the Radioisotope Thermal Generator (RTG) to be used on the Galileo and Ulysses spacecraft. The concern is with the possible spread of radioactive material if there is a catastrophic destruction of the SRB's and ET's during pad or

ascent phases, or during a landing as the result of an aborted mission. The Panel has not had a review of on-going activities except to note that they are many and diverse in nature. Suffice it to say that the Panel believes that adequate management and technical attention is being paid to RTG concerns.

10. NASA Aircraft Operations

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

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

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

Step 3. Cause to be published a memorandum for each Program Associate Administrator having line responsibility over centers with aircraft directing the implementation of certain policies and procedures which have

been established by Headquarters but to date have received limited acceptance by some centers. This step was completed in October 1984.

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

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

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

We plan to monitor the X-29A project through its early phases of flight testing. This includes attending appropriate sessions to observe and participate in the evaluation flight test results and future vehicle testing. Plans are to fly the airplane within a limited flight

envelope until early May 1985 when the airplane will begin two months of downtime to receive an updated flight control system prior to resuming further flight testing.

New technology items of interest include:

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

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

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

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

AUG 30 1984

Dear John:

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

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

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

Enclosure

1. Product Quality and Utility

ASAP Recommendation:

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

NASA Response:

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

Reports so far indicate that the centers and their prime contractors have enthusiastically taken to this initiative. As an example, Level II at JSC has recently issued a directive to all their projects requiring field reviews of hardware to determine the occurrences of unknown failure modes and premature wear, thereby checking qualification and verification program results. The Level III Orbiter Program Office has initiated a Product Quality Improvement Council at Rockwell, which includes Rockwell and their subcontractors. It is "results" oriented and provides meritorious citations where quality and usability have remained at a high level or have shown improvement. The results of these efforts show an overall reduction in the number of nonconformance reports. Rockwell has initiated several personnel and hardware programs to enhance product quality such as their Product Quality Assessment Team that examines the hardware at the

subcontractors, and their Employee Motivation Program that rewards plant personnel based upon peer nominations. In addition, all quality plans are approved by the President of the Orbiter Division. Production/productivity quality reviews are held quarterly, thereby providing for lower level information to reach top management.

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

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

2. Space Shuttle Main Engine (SSME)

ASAP Recommendation:

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

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

NASA Response:

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

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

3. Landing Gear

ASAP Recommendation:

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

- a. The practicality of converting to a four-wheel main gear truck within the present wheel well.
- b. The practicality of putting an extended or extendable strut on the nose gear for the purpose of changing the Orbiter ground attitude (more positive angle of attack), thus relieving the main gear roll-out loads.
- c. The feasibility of increasing brake capacity by a major percentage (at least 25%).
- d. A thorough review of the weak points on the present gear followed by suggestions for beef-up to bring the margins into partial comparability with the margins of modern transport aircraft in the landing mode.

NASA Response:

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

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

- (1) Addition of flight instrumentation. This has been approved for implementation and is being installed on Challenger for its next flight. The redundant instrumentation being used should be sufficient to characterize the brakes' dynamic performance characteristics under actual flight conditions.
- (2) Provision for hydraulic system damping. This is now in work at Crane Hydroaire for evaluation to determine the proper orifice sizing.
- (3) Modifications of the brake hardware. The 360° saddle has been installed on the two outboard wheels for STS 41-D. Clips for the beryllium drive lugs are being redesigned and will be available for STS-41G. The wheel lug/spline covers are being redesigned for deeper contact between the wheel and brake and will be available for 41G.
- (4) Modifications to the crew pedal. This is a simple change which will be accomplished after the crew input on their requirements.
- (5) Testing of the carbon liner material. These tests have been conducted to characterize carbon liner material as input data for the math model of the brake system.
- (6) Provide measurements of vehicle structure. This has been approved to provide data for the math model.

- (7) Develop a math model. This is being accomplished both at JSC and Rockwell. It is expected to be completed in about 6 months.
- (8) Perform dynamometer testing at Wright Patterson. Dynamometer testing is being performed at Goodrich.

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

- a. The 4-wheel truck would require a major gear design change and extensive modification to the Orbiter wings to increase the landing gear compartment size. This change would be very expensive, and the vehicle would have to be used as a test bed.
- b. The longer nose gear would reduce the tire loads imposed on the main landing gear and improve the single tire rollout capability. However, the tires, along with the wheels and bearings, have been shown to provide adequate margins. Although the longer gear design is possible, it is not simple and would introduce additional failure modes if it were to be fitted within existing structural interfaces. It would cost about \$50M and take about three years to develop. However, with recognition to the ASAP point, we are still giving redesign (extension) consideration to provide the optimal load relief for the minimal program impact.
- c. It is feasible to increase the brake capacity by 14 percent using the existing wheel. The payoff would not be significant that is, an increase of only several knots in the landing speed would result. The present design will stop the vehicle in about 2500 feet after application of brakes. That additional 14 percent capacity would shorten the landing distance by about 100 feet. Greater increases in brake capacity could be accomplished using structural carbon but would require redesign of the wheel system. The present beryllium carbon brakes are already designed to cover abort landings up to the maximum (240,000 pounds) landing weight allowed. The greatest braking capacity is required during emergency braking which imposes an energy level of 55 million foot-pounds per brake or 220 million foot-pounds for the entire vehicle. The emergency capability of 55 million foot-pounds per wheel has been demonstrated during dynamometer tests at Goodrich. The energy used for the first 10 Shuttle flights has varied from 26.7 to 142.2 million foot pounds per vehicle so a substantial margin exists. A maximum pressure braking test for a short duration of time was conducted on STS 6, the result being the shortest rollout distance achieved

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

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

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

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

4. Logistics and Maintenance

ASAP Recommendation a:

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

NASA Response:

The Office of Space Transportation issued on May 1, 1984, the "National Space Transportation System, Space Shuttle Integrated Logistics Support Policy" (SFO PD-110.5.). That

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

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

ASAP Recommendation b:

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

NASA Response:

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

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

ASAP Recommendation c:

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

NASA Response:

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

- (1) Develop plans for long-term support from off-site maintenance facilities.
- (2) Establish a responsive and reliable transportation pipeline to assure timely and damage free movement of SPC material.
- (3) Review subcontractor and vendor support for element hardware to ensure that the most economical sources are being used.
- (4) Maintain accountability and control of all SPC spares and equipment.
- (5) Develop an approach with NASA/KSC/JSC/MSFC to minimize the risk associated with out-of-production flight hardware and associated support equipment.
- (6) Provide a logistics support system that uses a common data base for provisioning and reporting that is visible to users at KSC and Vandenberg Launch Site.
- (7) Establish provisioning models that will ensure an adequate depth of spare and repair parts to efficiently and economically support the mission model.
- (8) Provide a method of tracking repairables in the repair cycle to encourage a timely maintenance repair program that is responsive to need dates and that provides maintenance data for adjustment of range and depth of spare/repair part inventory, adjustment of maintenance activities, and collection/control of maintenance costs.
- (9) Develop a logistics launch readiness review system that has a milestone for each mission.

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

ASAP Recommendation d:

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

NASA Response:

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

5. Orbiter Structural Loads

ASAP Recommendation:

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

NASA Response:

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

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

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

6. Orbiter Landing Speed and Pitch ControlASAP Recommendation:

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

NASA Response:

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

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

7. Shuttle Processing Contractor (SPC)

ASAP Recommendation:

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

NASA Response:

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

The SPC is now on-board. Although they have been highly successful in hiring personnel who have prior Shuttle experience, the level is not of a degree that precludes NASA involvement. New organizational techniques are used by this contractor, but the management is operating in a takeover mode. What this means is that Lockheed had planned and proposed to provide a service to NASA that had been organized strictly for operations, not taking into account the realities that some integration tasks are still being implemented as we move toward an operational vehicle. The Lockheed proposal presupposed that a logistics program

is in place and that no launch vehicle modifications would be necessary. Thus, a straightforward standardized mode of operation was assumed. This, of course, did not permit sufficient leeway for accomplishment of vehicle improvements, and NASA involvement at this time has necessarily become greater than what SPC had anticipated before the award of the SPC contract. After vehicle change activity is reduced, KSC will be in a position to proceed with full operational utility. However, this delay could be to our advantage since we need to carefully deliberate all changes to a successful system.

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

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

8. Safety of Flight Operations

ASAP Recommendation:

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

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

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

NASA Response:

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

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

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

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

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

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

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

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

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

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

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

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

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

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