The Panel will continue to monitor the program actively as it progresses. In particular, we plan to attend the several design reviews, test program reviews and program reviews which are scheduled during the coming year.

Appendix 3

PAYLOADS

With the focus of the Shuttle program shifting from development and flight test to operational use, the Panel has increased its emphasis on the review of the payloads to be transported by the Orbiter. Summary observations on a number of the payloads examined follow.

Orbital Refueling Demonstration

The Panel was represented at the first design review meeting and at the Phase I/II safety review meeting for this project. As would be expected, the focus of safety concerns is the presence of hydrazine in the experiment. Of principal concern are: The possibilities of hydrazine leakage, adiabatic detonation, ullage recompression, exposure of the crew to the propellant etc.

Much progress has been made since the first design review meeting. Among the changes since the first meeting is the elimination of all catalytic vents of the hydrazine side of the system. Each potential hazard is being analyzed methodically and the design is being scrutinized in a thorough manner to assure that the system meets all NASA safety criteria. One open issue is how to treat the possibility of an astronaut getting his EVA suit contaminated with hydrazine and assuring it is clean before entering the air-lock.

The system design is progressing well. There is a very good team on the job. Much work remains to be accomplished prior to the scheduled flight date. Continued thoroughness of design and safety review coupled with satisfactory completion of the test program is required to reduce the risks to acceptable levels. The Panel will continue to monitor this project.

Spacelab

The Panel was represented in the Phase III safety meetings which were the final safety reviews for Spacelab I. There appeared to be great depth and thorough analyses of payload safety as indicated by the representatives of the participating centers.

It appears to the Panel that the project has been well managed. The matrix format that was utilized was designed to assure that each item was evaluated for individual hazards and the consequence of each such failure on its system. Further, interface analyses had been conducted to assure that each system does not impact adversely on other systems and on the entire payload. Final approval of the results of the review rested with the STS project.

It is suggested that the Panel be kept informed about schedules and plans for such safety reviews at their inception so that it may begin to observe the process as early as possible. With such early involvement, it would be possible to gain a broader comprehension of the payload project and the issues that arise thus permitting the Panel to render a more informed and, therefore, complete assessment.

Appendix 4

EXTRAVEHICULAR ACTIVITY

Suits and prebreathing

Extravehicular activity (EVA) is increasing as the STS project reaches out with new and more sophisticated programs. All EVA has been conducted to date using a 4.3 psi suit. As far as the Aerospace Safety Advisory Panel is aware, all EVA activities have been routine except for the first flight. The current suit, because of its low operating pressure, requires an extensive period of prebreathing of 100% oxygen (up to 4 hours) prior to attempting an EVA from a 14.7 psia cabin. This precaution is necessary to avoid decompression sickness (bends) of astronauts when going EVA.

On mission 41-B (STS-11) the cabin pressure will be reduced from the normal 14.7 psia to 10.2 psia before initiating EVA to acclimate the astronauts to the lower pressure. This allows prebreathing time be reduced to about 40 minutes as well as decreasing the astronaut's susceptibility to decompression sickness.

For the future, research is being conducted on a higher operating pressure suit at 8+ psi. This new suit design is to have much greater flexibility in the shoulder, arm, and leg joints, than that of the current suit. The new design has the capability of greatly reducing or eliminating prebreathing requirements.

It is the view of Aerospace Safety Advisory Panel that as time progresses there will be an increasing need for the higher pressure more flexible suit. While current NASA plans may not require this new design, we can visualize the increasing need for it as missions become more complex and the Air Force begins to use the STS for its own missions. The ability to go EVA with little or no prebreathing is a big plus. The greater flexibility of the new design when combined with the proven torso of the existing design should decrease workload of the astronaut and reduce his susceptibility to decompression sickness.

We believe that NASA should foster the full development of the higher pressure suit and when fully tested it should become the standard suit for all future EVA activities.

Manned maneuvering unit

This short range versatile spacecraft, the manned maneuvering unit (MMU), has been conceived for use as a controllable platform which can transport an astronaut on a short radius from the Orbiter payload bay to satellites near the Orbiter or to inspect the external surfaces of the Orbiter itself. The purpose for the transportation of the astronaut is to place a member of the crew in a position to inspect, repair, and help retrieve satellites whose orbits can be reached by the Shuttle. Sufficient control power is designed into the MMU to permit the passenger astronaut to use the thrusters on the MMU for controlling the motion of randomly moving satellites and to tow them back to the Shuttle for repair or return to earth.

The concept of the MMU and its systems, along with the operational plans and developed capabilities, was reviewed by an Aerospace Safety Advisory Panel member at the contractor's plant (Martin-Marietta in Denver, Colorado). In addition, the simulator work, the facility, and the training program were also described and shown. Simulator training was assessed along with methods for coupling the astronaut to the Solar Maximum Mission (SMM) satellite. Similarly, the adapter hardware and procedure for attaching the MMU to the payload bay wall was viewed as part of the total description of how the "space-suited" astronaut mounted the vehicle, detached it from the payload bay wall and reattached it once the mission was completed.

From this individual but thorough review, the Panel notes:

a. The concepts of redundancy for critical systems are consistent, the systems are simple and sufficiently exposed to permit thorough inspection.

b. The cold gas thrust and attitude control system is susceptible to pre-use inspection prior to disengagement from the Shuttle bay wall.

c. The gauge indicating energy available to the thrusters was in a poor position for visual monitoring while the astronaut was secured in the unit's seat. It seemed feasible to move this gauge without destroying the integrity of the systems tests that have been run.

d. The training program has been developed pragmatically along with the unit and appears to be effective. After the first experimental flight with the MMU this program and the formal documentation should be reviewed again by the Aerospace Safety Advisory Panel.

e. It was determined that no "safety" umbilical (tether) is to be used for the first experimental flights and is not contemplated for ultimate operatioanl use. This appeared to introduce unnecessary risk, but the astronaut trainer-director for the program explained that umbilical tangling and snagging represented a hazard judged to be equally severe and that the thruster system of the MMU did not have enough capacity, even if stuck in "full thrust", to move the passenger out of range of the Shuttle capability for astronaut rescue. Additionally, the "buddy system" provides that a second astronaut in the regular EVA suit will be there.

Based on discussions at the MMU Critical Design Review held November 1983 an additional comment can be made: If, for any reason, there are significant amounts of dust/debris in the payload bay during ground or flight operations, care should be exercised to prevent MMU pneumatic systems from being contaminated which might adversely affect their operation.

Appendix 5

LOGISTICS, MAINTENANCE, SPARES AND OPERATIONS

This discussion is based on three specific activities: (1) General Abrahamson's meeting at Kennedy Space Center in November 1982, (2) attendance at a logistics telecon at Rockwell International, Downey, California, in April 1983, (3) visit to Vandenberg Air Force Base in October 1983. In addition, major events have occurred during 1983 which have direct bearing upon the subject:

a. Creation of the Integrated Logistics Panel (ILP) and commencement of working liaison with Vandenberg AFB. This is noted in a Program Directive, SSPM No. 85A issued by JSC's NSTS Office, March 25, 1983.

b. Issuance of an Integrated Logistics Support Policy (ILSP) for the National Space Transportation System establishing a platform for (a) above.

c. The award to Lockheed of the Space Shuttle Processing Contract (SPC).

The meeting at Kennedy Space Center convened by Gen. Abrahamson on November 9, 1982 was the catalyst for the more vigorous logistics, maintenance and support activities which have gradually evolved during 1983.

The Integrated Logistics Support Policy is commendably detailed with seven appendices: Management policy, spares policy, maintenance and repair policy, logistics support functions policy, ILS milestones, ILS definitions and ILS top level documentation tree. It would appear that a number of management level people in both NASA and USAF are looking to the establishment of the Lockheed-managed SPC as a partial answer to many logistics problems but, although the ILSP was produced concurrently with the contractor-selection award process, the directive does not cite an SPC role in this arena. It is too early to be able to gauge the effect of the SPC program upon logistics but clearly it must necessarily be heavily involved, at both KSC and VAFB.

With respect to the scope of the ILP task, there is concern that it does not include logistics for the Spacelab, Centaur, IUS and PAM elements. It certainly appears that only a complete system ILS program, that is, including the vital payload elements, would have the desirable result of ensuring that the vehicle launch dates can be met from the support viewpoint.

The issue raised by the Aerospace Safety Advisory Panel in earlier annual reports, namely, that of providing logistics control by a single entity appears to remain for the future. The cooperation and growing cohesion of the USAF-Vandenberg and the NASA-JSC/KSC elements is very encouraging but the co-chairing arrangements of the ILP, necessary as they may be at present, do not make for efficient operation in trying to recover some of the critical time lost over the past three years.

The task of the ILP is greatly complicated by the necessity of trying to match the USAF well-developed organizational and management systems with the equally well-established "three-level" system at NASA. This results in a number of organizational "wiring diagrams," interface and procedural documents, few of which, at this writing appear to be completed.

While the issues of supply of components at the line replaceable units (LRU) level appear to be documented and understood some of the necessary suppliers may not be funded. Progress is most certainly being made in detail components but major units such as the SSME with its critical sub-assemblies still are in need of a good, clearly established master plan.

There is also the logistics aspects of transporting the SRB segments to VAFB which are in need of reinforcement for which the case for a third set of rail cars is being made.

Storage space at KSC for SRB segments is limited (although VAFB seems to be better off in this respect) and there is clearly a need for a study involving a "transportation model" to resolve some of these issues before they become a trans-continental transport crisis. In this general context the critical dependency upon only one B-747 Shuttle ferry vehicle for coast-to-coast movement should be re-examined.

Based upon our observed development of the logistics spectrum over the past year it appears that:

a. Considerable progress has been made in trying to gain control of the logistics problem. Improvements in NASA's interest and organization for Integrated Logistics System and sincere cooperation and coordination by USAF for the projected VAFB operations are certainly showing results.

b. There still appears to be issues associated with who has the responsibility for Orbiter, that is to say between the USAF and NASA. (The Directive says that the Air Force has responsibility for it "on-orbit." This needs clarification.)

c. The "reporting to" functions of the Integrated Logistics Panel (ILP) are still unclear. Should, for example, the ILP report directly to the National Space Transportation System Program Office? Should the ILP functions also embrace logistics aspects of operation and launch instead of being limited as at present to supply and support tasks? The charter of the ILP, in spite of well-written directives from NASA Headquarters and Johnson Space Center is still unclear.

d. Considerable worry has been voiced throughout the year about the lack of ILP access to the Spacelab, Centaur, Inerital Upper Stage, and Payload Assist Module systems and the question therefore arises: is the ILP intended only to support Shuttle and not the broad spectrum of NSTS which would include these payloads?

e. The USAF view seems to be that they can't see anything in the NASA system at present which could be recognized as a well-developed maintenance, supply and logistics curriculum such as the USAF have developed and refined over the years. On the other hand, it appears that the evolving NASA logistics programs are more suited to the special problems of the small Orbiter fleet than the highly-structured, large fleet concepts of the USAF. Providing a workable accommodation between these two opposing philosophies would seem to be a pre-requisite for the ILP but it must be empowered by directive to be able to bring about such a foundation.

f. The "co-chairing" of the ILP by USAF and NASA is clearly the only arrangement which could be employed at this stage. Perhaps it is too early to establish the function of an overall "czar" of logistics but the difficulties which are beginning to show up from this rather too democratic co-chairing process could probably be short-circuited by the early appointment of a strong top chief with total authority.

g. The role of the SPC in the entire scheme of things needs to be determined and made visible to all concerned as soon as possible if some of the program's aspirations are to be realized.

Appendix 6

SPACE TRANSPORTATION SYSTEM ELEMENTS

Orbiter Landing Speed and Pitch Control

The Aerospace Safety Advisory Panel has, in the past, called attention to major deficiences in handling qualities of the Orbiter. These deficiencies are well known, highlighted by substantial pitch gyrations during the Approach and Landing Test No. 5 and some subsequent landings. Such control perturbations have been examined by analysis and numerous simulator control explorations. The Aerospace Safety Advisory Panel believes that NASA top management should direct further exploration of the significant benefits to be gained by major changes to improve the pitch control of the Orbiter.

The latest information that the ASAP has found on this problem is a report of the flight control system testing done on the Ames Vertical Motion Simulator (VMS), entitled: "Evaluation of the Space Shuttle Approach and Landing Flight Control System Handling Qualities" by S. D. Griggs, R. J. Grabe, and S. R. Nagel. This study, carefully conducted over a period of several months, by competent engineers and pilots with extensive experience in high performance airplanes and Shuttle simulations, resulted in the following recommendations:

a. Do not replace the current Flight Control System with any of the alternate systems evaluated. Some were found to be slightly better, but not to the extent that a change to the baseline system is warranted.

b. Investigate the feasibility of improving the low speed handling qualities of the Orbiter through airframe modifications, such as the addition of canard surfaces.

Eight different flight control systems were evaluated including software modifications to filters, gains, feedback paths, senor, etc. Ten pilots flew approaches to runways simulating Dakar, Kennedy Space Center, and Edwards Air Force Base. Disturbances were introduced during the approaches to stimulate transients in sensor data, such as changes in radar altitude, in azimuth from the microwave landing system, head/tail winds, and reduced visibility return as in a breakout from low cloud deck. The Heads Up Display (HUD) was not used.

The results show substantial variations in touchdown point, airspeed at touchdown, and vertical speed at touchdown ($\dot{h}$). Different software "improvements" failed to show significant changes; -- and there were a number of "crashes". A "crash" is defined as landing short or long or left or right or with $\dot{h}$ greater than 10 fps.

Pilot comments on the baseline system were:

> "Easy to balloon under stress"
> "If aircraft disturbed, end up hunting for ground"
> "Cannot control aircraft precisely near ground"
> "Lag between rotational hand controller (RHC) and vehicle response causes over control for large inputs and undercontrol for small inputs."

These comments on the performance of the recommended system indicate that there is a basic pitch control problem in the aerodynamic design of the Orbiter.

It appears that the attempt to combine pitch and roll control with lift augmentation by the use of elevons on a delta wing results in compromises that have penalized both pitch control and lift augmentation.

The pitch control problem arises from the fact that, on the landing flare, to reduce airspeed, the pitch up moment is accomplished on the Orbiter by raising the elevons which inherently decreases lift coefficient with loss of lift, increasing the landing speed. The loss of lift is in response to a control motion that a pilot normally uses to raise the nose and increase lift! In addition, the inertia of the Orbiter is such that the motion of the c.g. lags the control input by as much as two seconds. The lag and apparent lift reversal can induce over control, and, in some cases, severe pilot induced oscillation (PIO).

The use of canard surfaces to provide pitch control would free the elevons to be used for lift augmentation and roll control. The elevons would have to be limited in droop to maintain adequate roll power but in spite of this, the available increase in lift would be most significant. Estimating from a nominal landing speed of 175 knots, angle of attack of 10^{o}, elevon angle of 0_{o}, produces an apparent lift coefficient of 0.41. Using the elevons as landing flaps with a canard trimmer might produce double this lift coefficient with a possible landing speed of 125 knots.

The above increase in lift coefficient is not impractical. The advantages of such a landing velocity reduction are very significant from a <u>safety</u> viewpoint:

a. Stresses on wheels and brakes are reduced
b. The risks of landing at Dakar or other short fields are reduced, opening up many alternate abort sites
c. In the event of ditching in the open sea, the probability of survival would be greatly enhanced.

One of the significant findings in the Ames Vertical Motion simulator tests was an appreciation of the dangers of attempting a high-weight low-speed landing (like an abort to Dakar). If the angle of attack is increased much above 10°, in an attempt to land slowly, the aerodynamic condition is one of "backside of the L/D curve" where the induced drag rapidly decelerates the Orbiter and increases the sink speed.

In addition to the safety aspects of low landing speeds, the avoidance of pilot induced oscillation must be emphasized. To the non-pilot, the term "pilot induced oscillation" is just that: a disturbance that is felt to be controllable and transient. To the pilots who have experienced it, including the astronauts, it is recognized as a potentially uncontrollable instability. The lack of a landing incident to date is a tribute to the skills of the astronauts, and to the carefully planned and executed training program in high performance aircraft, the Shuttle Training Aircraft, and simulators.

Space Shuttle Main Engine

The current year began unauspiciously for the Space Shuttle Main Engine (SSME) with the discovery of leaks in the STS-6 engines and the resultant delays in scheduled flights. There were a number of intensive reviews of the problems and their systems and management implications. Panel members participated in several of these reviews. Corrective actions were devised and implemented. Subsequently, the engines performed essentially as predicted in all the flights this year. During the STS-8 flight an Augmented Spark Igniter line failed during the shutdown sequence. This had no effect on the mission. The cause of this failure has been identified and corrective action implemented.

Because of the very limited life (one or two flights) demonstrated by the turbomachinery during the FPL (109%) certification test program and in the absence of near-term flights requiring that thrust level, it was decided to limit planned flights to 104% thrust. Such "derating" is a prudent step. Not only does it provide added operating margin for the SSME, it also should result in longer useable life for the turbomachinery. This should mitigate the logistical problems that would be caused by the need for frequent change-out of turbopumps that are operated at 109%.

The SSME project has embarked on a three-phase program to achieve a long-lived, reliable full power load (FPL) engine. The first phase involves conducting certification extension tests at 104% to obtain more data on durability at that thrust level. The second phase comprises the orderly development, certification and incorporation of a set of design-detail modifications aimed at solving some of the problems encountered with the current FPL design. The third phase includes major redesign changes. Among them are: Redesign of the Hot Gas Manifold to eliminate non-uniform flows and accompanying parasitic pressure losses; elimination of injector baffles and shields, and increasing the throat diameter of the nozzle. All of these changes will tend to "unload" the turbomachinery thus providing greater operating margins and, hopefully, extended useful life. Also included in the plan are steps to provide new turbopump designs should the preceding not prove effective.

The Panel supports this organized approach to solving the problems of the SSME. Such a program is necessary to provide a reliable engine for higher-power operation and to reduce the logistic burden of frequent component removals.

The Panel would like to emphasize that it is important to set the objectives of this improvement program in terms of <u>demonstrated margins</u> of stresses, temperatures, loads, etc., rather than primarily in terms of time at a given thrust level. Stipulating margins gives recognition to the fact that time-to-failure curves are extremely sensitive to stress, temperature, etc., in the vicinity of the ultimate stress limits of materials. This is especially true when materials are operated at the high temperatures that prevail in the SSME.

Having demonstrated such improved margins by, among other things, operating the engine at thrust levels above 109% it is of utmost importance to not fall into the trap of considering the engine to be "rated" for operation at the higher thrust level. What has been accomplished is to have demonstrated that there is a margin for operation at 109%. To operate at the highest level tested would be, in essence, to operate without margin.

The Panel will continue to monitor the progress in the program during the coming year.

Orbiter Structural Integrity

The Orbiter structure was designed to loads that have acquired the name "ASKA 5.1." A later set of loads (now called "ASKA 5.4"), based on revised aerodynamic and thermodynamic data, was used for the most current structural assessment. Flight data analyzed to date (strain gage readings recorded on flights STS-1 through STS-5) have not shown reasonable agreement with predicted strain for the same locations using ASKA 5.4 loads. Even though these initial flights were designed to be as benign as possible, the ASKA 5.4 predicted limit strain on the wing alone was exceeded in:

a. 63 instances during ascent
b. 41 instances during descent

Fortunately, there were no instances where the measured strain exceeded a safe allowable limit strain. The numerous exceedances of ASKA 5.4 predicted limit strains without exceeding safe limit strains could be due to:

a. the ASKA 5.1 loads that were used for <u>design</u> were more severe than the ASKA 5.4 used for <u>assessment</u> in the areas where exceedances were measured

b. larger than minimum margins of safety were accepted and used in the design.

Since flight development was officially concluded with STS-5, the development flight instrumentation installed in OV-102 has essentially been dismantled. There does not seem to be an adequate plan to acquire the in-flight data required to close out the discrepancies between flight and analysis data. Therefore, the following steps should be taken:

a. Vehicle OV-102, which was the most densely instrumented vehicle, should have all DFI (Development Flight Instrumentation) gages reactivated and duplicated on both sides of the vehicle and should have adequate pressure measurements added in order to establish a more complete data base.

b. The initial flights were designed to be as benign as possible. With the flight envelope being expanded with each flight, instrumentation should be required on <u>all</u> vehicles in order to safely monitor future flights.

The failure of flight data to validate the current best predictions of structural loads raises serious questions about how the full strength of the Orbiter vehicles can be safely exploited. The Panel views the present situation as follows:

a. ASKA 5.4 loads apparently do not have the correct distribution of aerodynamic forces in the ascent configuration.

b. Current analytical prediction of internal loads and identification of the most critical elements for structural failures are not valid.

c. OV-103, OV-104 and OV-105 wing structure will be more critical than earlier vehicles because of the 800 pounds of structural weight removed in a weight reduction program. The reduction was based on adhering to close margins on ASKA 5.4 loads which, in some areas, were less than the ASKA 5.1 loads used for the original design. Thus, the failure to validate the ASKA 5.4 loads has particular significance for these later vehicles.

d. Future plans include missions that can experience 11% more dynamic pressure (Q) on ascent and 60% higher heating rate on descent than has occurred on STS-1 through STS-5. The best way to prepare to safely fly the most severe mission should be addressed.

Vehicle 6.0 Loads/Stress Analysis

Since the time that the ASKA 5.4 loads were derived (in 1976/1977), both flight and wind tunnel data have been developed that should provide a better basis for generating loads that more closely represent those being experienced by the full-scale flight vehicles. It has been proposed that a new set of loads be derived and used with an updated finite element model to provide a basis for establishing safe structural limits for future flights. This proposed effort has been called the 6.0 Vehicle Loads/Stress Analysis.

The vehicle 6.0 loads/stress analysis would consist of a complete update of the dynamic, thermal and mechanical loads math models that takes into consideration all structural configuration changes resulting from the OV-103 weight saving efforts and other Shuttle element (ET and SRB) modifications. The followng should also be re-evaluated: aeroheating and thermal gradients, aerodynamic and compartment venting pressure loads, weight distributions, inertia loads, ascent trajectories, and the effects of the redesigned landing gear metering pin. These efforts should be coordinated with the latest wind tunnel and flight test data results in order to establish a new internal loads data base for ascent, descent, and landing conditions. These loads would then be used as a basis for a new stress analysis to establish the operational capability of the vehicle.

The Aerospace Safety Advisory Panel believes that another round of loads analysis of the 6.0 type is necessary in order to safely utilize the full potential of the Orbiter structure.

Filament Wound Case (FWC) For Solid Rocket Boosters

Results of a full-scale hydrotest of two segments of the FWC were reported at the Technical Interchange Meeting at Morton Thiokol, Wasatch Division, on November 16-17, 1983. Full-scale test specimens TFS 2 and TFS 3 were pinned together with proper end closures and external tank/solid rocket booster interfaces and successfully completed hydrotesting on October 21. The test results are as follows:

a. The test ran four maximum expected operating pressure (MEOP) cycles to 1050 psi with a final test to 1478 psi without burst.

b. The fiber strength in TFS 3 was demonstrated to 442 KSI.

c. The factors of safety (F.S) were shown to be:

   1.50 Factor of Safety in the membrane for TFS 3
   1.42 Factor of Safety in the membrane for TFS 2
   1.32 Joint Factor of Safety for All Joints

d. The test specimens show no signs of delamination or wear.

e. All test objectives were met.

Two more full-scale specimens are scheduled to be hydrotested to 140% of maximum expected operating pressure by the middle of January 1984. These tests if as successful as the tests of TFS 2/3, will provide adequate certification of the FWC structural design.

Lightweight External Tank

In last year's annual report the Aerospace Safety Advisory Panel recommended that a nonlinear buckling analysis be performed on the Lightweight External Tank (LWT) structure in the area of the LH_2 tank where maximum compressive stresses are produced by thrust from the Orbiter. This analysis has now been completed by Martin-Michoud, and the method and assumptions have been reviewed and approved by an independent consultant, Mr. David Bushnell, of Lockheed Missiles and Space Company. The results show the LWT to have a 60% margin of safety in compression above the design ultimate load. This will add to the 26.5% margin of safety between the design ultimate load and the design limit load. With these analytical results in mind, the Panel is satisfied the LWT is structurally stable for 109% of SSM rated power level.

Landing Gear Design

For many years the ASAP has been pointing out the inconsistency of the landing gear design loads where the Orbiter has departed from commercial design practice. Normal commercial transport aircraft have built-in margins for the maximum loads expected in landing and braked roll-out conditions since the critical loads are normally refused take-off with braking and a 1/2g turn. Thus comparison with transports show:

	DC-9	L-1011	Orbiter
Max design load equals max stress (% max stress)	100%	100%	--
Braked roll-out (% max stress)	73%	58%	100%
Touchdown at 10ft/sec (% max stress)	71%	34%	--
5ft/sec (% max stress)	--	--	100%
Static load (% max stress)	48.4%	21%	38.7%
Tire deflection (max Ldg Load)	33%	--	66%

In spite of the fact that brake energy (design) has been based on abort landings at 240,000 lbs. there have been actual or incipient brake failures on almost every landing even though landing weights have not yet approached the design maximum valve. A review of the brake energy utilized through STS-5 shows that the pilots have been demanding ever increasing energy. STS-5 used an average of 35.54 millions of foot pounds with a maximum on one wheel of 42.62 millions of foot pounds. This value compares to the maximum energy for emergency use of 55 million foot-pounds and a fuse setting of 42 million foot-pounds, illustrating the marginal capacity of the brakes.

It has been noted by Robert Rothi that the brake pedals require a 75 # force to achieve maximum brake pressure of 1500 psi. This apparently is extremely difficult for the pilot to do consistently because of the long, tiring mission and not applying full force lengthens the stopping distance appreciably. Here is a PRIME situation to incorporate an "autobrake" system. Autobrakes are currently in production use on the 747, DC-10, DC-9, and other airplanes and the systems have been well-developed. Adaptation for use on the Shuttle should be a simple process and would relieve crew workload and result in shorter, consistent stopping distances.

The brakes were initially designed for 3000 psi, but the torque from the carbon-carbon rubbing surfaces peaked so high near the end of the stop on dynamometer tests that B. F. Goodrich, the brake supplier, was afraid of structurally failing the stators and rotors. Hence, the addition of reducers and the reduction of maximum brake pressure to 1500 psi to limit the peak torque.

Repeating again some of the Aerospace Safety Advisory Panel recommendations, it is suggested that NASA:

a. Seriously study the use of a longer nose gear strut or the installation of an expanding nose gear strut to relieve the roll-out loads in landing,

b. Similarly study the feasibility of a 4-wheel truck main gear.

Short of such a major change there are a number of less extensive improvements that NASA should seriously address including:

a. Place the Shuttle main gear tires on a flat surface on individual load cells at the end of a mission and record variation in load distribution across the Shuttle. It appears that structural deflections on landing must tilt the shock struts outward loading up the inboard tires to higher loads and causing those brakes to absorb more than their proper share of the energies.

b. Move the main tire centerline inward toward the shock strut about one inch and increase the tire size as much as the diametral clearances will allow, maybe H46x17-22, or bigger, with a 5° bead seat.

c. With the larger tire and internal wheel space redesign the brake for greater energy and torque capacity using structural carbon. Support the brake on the axle near the inboard bearing to minimize axle bending.

APPENDIX 7

PANEL ACTIVITIES FOR CY 1983

As in previous years, Panel fact-finding sessions have been conducted on the average of four times per month for 1983. Members and consultants have during this same period visited seven NASA centers and facilities (Ames Research Center, Dryden Flight Research Center, Langley Research Center, Lewis Research Center, Johnson Space Center, Marshall Space Flight Center, Kennedy Space Center) as well as NASA Headquarters, and numerous NASA contractors. Although these have been focused on the Space Transportation System, there have been a number of fact-finding visits aimed at reviewing and assessing aeronautical operations and attendant flight safety. The Panel has, where practical, participated in a number of significant in-house reviews; e.g., Flight Readiness Reviews, various project hardware/software technical meetings, STS Support Activities. Panel efforts have been supported by the Panel Staff Director through in-depth and continuous participation and reviewing of STS and other program/project activities as well as aeronautical R&D and administrative flight safety activities.

The breadth of Panel personal discussions goes from the NASA Administrator and Deputy Administrator to Program Directors on into the subsystem design and test personnel (the "hands-on" people). Beyond this is the Panel's annual report provided to the NASA Administrator, informal meetings with Congressional staffs, and testimony before the appropriate House and Senate subcommittees in January-March period. Where requested, the Panel provides individual support to special review teams such as those looking at the Filament Wound Case for the Solid Rocket Motor, Centaur/Shuttle Safety, and the Shuttle Main Engine Assessment Group.

APPENDIX 7 CONTINUED

SUBJECT: Panel Fact-Finding Sessions Calendar year 1983

Date	Location	Attendance/Subject
1/28-29/83	KSC	STS-6 Flight Readiness Firing (Elverum/Grier)
2/4/83	Rocketdyne Div.	STS-6 Flight Readiness Firing (Elverum/Grier)
2/8/83	NASA HQ	Annual Meeting, 1982 Activities (Panel)
2/22/83	Hercules Corp.	SRM Filament Wound Case (Hedrick/Rothi)
3/2/83	Congress, DC	Panel Testimony to House of Representatives
3/3/83	KSC	STS-6 Flight Readiness Review (Battin/Grier)
3/16-17/83	KSC	Launch Processing Software/Hardware (Battin)
3/30/83	JSC	STS Program Management/Mission Ops (Hawkins/Grier)
4/4-8/83	JSC	Mission ops, aircraft safety, logistics for STS, Logistics Panel, Space Medicine (Parmet/Davis)
4/6/83	Rockwell, CA	Integrated Logistics Panel, Orbiter (McDonald)
4/14-15/83	General Dynamcis	Shuttle/Centaur Level II Reviews (Hawkins/Grier)
4/19-20/83	MSFC	STS Projects (SSME, ET, SRB), Spacelab, Space Telescope, Filament Wound Case (Panel)

4/21/83	NASA HQ	STS Logistics Programs/Policy (McDonald)
4/27-30/83	Rockwell, CA	Space Shuttle Main Engine/Orbiter (Himmel)
5/25-26/83	NASA HQ	TDRSS Ops, Orbital Communications (Battin/Davis)
5/31-6/1/83	JSC	STS Autoland, Flight Trajectories (Battin)
6/1-2/83	JSC	STS Autoland, RTLS abort, Crew Support (Davis)
6/2-3/83	JSC	Spacelab Safety Review (Parmet)
6/8-9/83	Hercules Corp	Filament Wound Case Status/Problems (Hedrick/Rothi)
6/10/83	NASA HQ	STS-7 Flight Readiness Review (Himmel)
6/14-16/83	KSC	Special SSME Management Review Team (Himmel)
6/27-30/83	ARC	Aviation Safety Inspection Review Autoland Simulator operation (Davis)
7/12-13/83	General Dynamics	STS/Centaur Integration and Ops (Panel)
7/14/83	Rocketdyne Div	Space Shuttle Main Engine (Elverum/Himmel)
7/25-28/83	LaRC	Aircraft operational safety (Davis)
8/11-14/83	JSC	Orbital Refueling Test Program (Parmet)
8/23-24/83	MSFC	Technical Interchange Meeting, FWC (Hedrick)
9/14/83	Martin Marietta,	Manned Maneuvering Unit (Hawkins)

9/13-15/83	NASA HQ	Intercenter Aircraft Operations Panel and NASA Aircraft Operations (Parmet/Davis)
9/28-30/83	KSC	Launch Preparations, Shuttle Processing Contractor transition, Aircraft Ops (Panel)
10/7/83	JSC	STS-1 to -8 Biomedical Symposium (Parmet)
10/18-19/83	JSC	Shuttle/Centaur Fluid Systems Safety Review RTG power supply cooling/control (Elverum)
10/19-20/83	MSFC	Filament Wound Case Technical Interchange Review/Meeting (Rothi)
10/19-20/83	VAFB	Integrated Logistics Panel for STS (McDonald)
10/18/83	Congress, DC	Informal meetings with Senate Staff (Hawkins/Grier)
11/8-10/83	JSC	Manned Maneuvering Unit Critical Design Review Orbiter Brakes, Crew Operations (Rothi/Davis)
11/10/83	MSFC	SSME, ET, SRB Production Quality Readiness Review with contractors/government (Grier)
11/16/83	JSC	Orbital Refueling System Safety Review (Parmet)
11/18/83	Brooks AFB, TX	EVA medical status and testing (Parmet)
11/18/83	NASA HQ	STS-9 Flight Readiness Review (Himmel)

11/30/83	Rocketdyne, Div	SSME 109% Rated Power Level Status (Hawkins/Grier)
12/2/83	KSC	Shuttle Processing Contractor's Status (Stewart)
12/6/83	NASA HQ	Orbital Maneuvering Vehicle, Transfer Orbit Stage, Tethered Satellite and its operations, Inertial Upper Stage status, activities review (Panel)
12/13/83	Nat'l Res Council	Filament Wound Case Special Committee Meeting (Roth)
12/16/83	LeRC	Centaur Critical Design Review (Himmel)

Appendix 8

PLANS FOR 1984

Panel Membership

A number of Panel membership changes are taking place at this time occasioned by events in late 1983. As noted in the front of this report, Robert D. Rothi's passing requires the selection of a new member. Lt. General Leighton I. Davis completed his membership term and has been retained as a consultant to the Aerospace Safety Advisory Panel. Bob Rothi had taken General Davis' position on the Panel. As a result of the selection of the contractor team which included Lockheed and Grumman to perform Space Shuttle Launch and Landing processing at Kennedy Space Center and Vandenberg Air Force Base both Willis M. Hawkins and Ira Grant Hedrick have retired from the Panel. They are remaining with the Panel in a phase-over period to accomplish a smooth transition to new members recently appointed in their stead.

Mr. John C. Brizendine former President of the Douglas Aircraft Company, now an aerospace consultant, has been selected to succeed Willis Hawkins as the new Chairman of the Aerospace Safety Advisory Panel. A brief resume follows:

> John Brizendine completed 33 years with the Douglas Aircraft Company in May 1983 after trying his hand at teaching at the University of Kansas after college graduation. His career included flight test work on a series of high performance research and development, military and commercial aircraft. This culminated in his promotion to Executive Vice President and then President of Douglas Aircraft Company in 1973. John served in the Navy as a Naval Aviator with single and mulit-engine ratings.

Mr. Charles J. Donlan has been selected to fill the vacancy left by Grant Hedrick. A brief resume follows:

> Charles Donlan had 37 years experience in research and development activities with NASA and its predecessor NACA before retiring in 1976. Most of this time was spent at Langley Research Center with the last 8 years spent at NASA Headquarters. Since leaving NASA he has been a consultant to the Institute for Defense Analysis with emphasis on assessing and making recommendations to the DoD on the development of facilities for the space Shuttle operations. His NASA/NACA experience included high speed research aircraft programs and direct involvement with all aspects of manned space flight since the beginning of such programs.

The selection of a candidate to fill the remaining membership position will be made in the very near future.

Panel Activities in 1984

Plans are to continue to focus on a number of aspects of the Space Transportation System as it approaches full operational status, assess the safety implications of upper stages and payloads that interface with the STS and to monitor the safety procedures and practices of NASA's aircraft operations.

Efforts will include at least the following areas of interest and concern:

- Shuttle Processing Contractor progress
- STS logistics and associated operational implementation

  - Orbiter
  - SSME
  - Solid Rocket Boosters
  - External Tank
  - Launch Processing System at KSC and VAFB

- Vandenberg Air Force Base operations and relationships with KSC

- Upper stages including the Inertial Upper Stage, Centaur, Transfer Orbit Stage, Orbital Maneuvering System

- Filament Wound Case for the STS Solid Rocket Motor

- Payloads and on-board experiments and their integration into the STS, for example:

  - Refueling Experiment
  - Spacelab
  - Tethered Satellite System
  - Galileo
  - Space Telescope

- Extravehicular Activity (EVA) and its support systems including suits, manned maneuvering systems and life sciences

- Rendezvous and proximity operations in space

- The Solar Maximum Mission spacecraft repair flight

- Space Station

- Certification policy and its implementation including product quality and design suitability, as well as, use of analyses versus tests

- Operational procedures to promote safety in the STS, space station and other programs

- Safety of NASA aircraft operations

AEROSPACE SAFETY ADVISORY PANEL

CHAIRMAN

Mr. Willis M. Hawkins (Retiring Chairman)
Senior Advisor Lockheed Aircraft Corporation

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

MEMBERS

Dr. Richard H. Battin
Associate Department Head
Charles Stark Draper Lab. Inc.

Mr. Charles J. Donlan
Formerly, Deputy Associate Adminstrator for
Manned Space Flight NASA

Mr. Gerard W. Elverum, Jr.
Vice President-General Manager
TRW Space and Technology Group

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

Mr. Ira Grant Hedrick (Retiring Member)
Presidential Assistant for Corporate Technolgy
Grumman Aerospace Corporation

Mr. John F. McDonald
Formerly, Vice President-Technical
TigerAir, Inc.

Mr. Norman R. Parmet
Formerly, Vice President
Trans World Airlines

Mr. Robert D. Rothi (deceased)
Formerly, Chief Design Engineer
Douglas Aircraft Company

Mr. John G. Stewart
Assistant General Manager
Tennessee Valley Authority

CONSULTANTS

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

Dr. Seymour C. Himmel
Formerly, Associate Director,
Lewis Research Center

EX-OFFICIO MEMBER

Dr. Milton A. Silveria
NASA Chief Engineer
NASA Headquarters

STAFF

Mr. Gilbert L. Roth
Staff Director, Aerospace Safety Advisory Panel

Ms. Susan Webster
Advisory Committee Assistant

ACRONYMS AND ABBREVIATIONS

AMO	Aircraft Management Office
ASAP	Aerospace Safety Advisory Panel
ASKA	Automatic Systems for Kinematic Analysis
DFI	Development Flight Instrumentation
EVA	Extravehicular Activity
FASCOS	Flight Acceleration Safety Cutoff System
FAMOS	Flight Acceleration Monitor Only System
FRR	Flight Readiness Reviews
FPL	Full Power Level
HUD	Heads Up Display
ILP	Integrated Logistics Panel
IAOP	Intercenter Aircraft Operations Panel
IUS	Inertial Upper Stage
ILS	Integrated Logistics Support
JSC	Johnson Space Center
KSC	Kennedy Space Center
LPS	Launch Processing System
LWT	Light Weight Tank
LRU	Line Replaceable Units
LaRC	Langley Research Center
LeRC	Lewis Research Center
MSFC	Marshall Space Flight Center
MMU	Manned Maneuvering Unit
NACA	National Advisory Committee on Aeronautics
NASA	National Aeronautics and Space Administration
NSTS	National Space Transportation System
OMI	Operations and Maintenance Instructions
OV	Orbiter Vehicle
PAM	Payload Assist Module
PIO	Pilot Induced Oscillation
RPL	Rated Power Level

RHC	Rotational Hand Controller
SMM	Solar Maximum Mission
SPC	Shuttle Processing Contract(or)
SRM	Solid Rocket Motor
SSME	Shuttle System Main Engine
STS	Space Transportation System
TDRSS	Tracking Data Relay Satelite System
USAF	United States Air Force
VAFB	Vandenberg Air Force Base
VMS	Vertical Motion Simulator