NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

JUL 8 1977

Reply to Attn of: MHQ

MEMORANDUM

TO: APA/Chairman, Aerospace Safety Advisory Panel

FROM: M/Associate Administrator
for Space Flight

SUBJECT: 1977 Annual Report on the Space Shuttle

We have reviewed the Panel's 1977 Annual Report. The Program response to the observations and recommendations is enclosed.

John F. Yardley

Enclosure

NASA's Response to Comments
made in the
Aerospace Safety Advisory Panel Annual Report
on the Space Shuttle Program
dated March, 1977

Enclosure

Subject: ALT Mission Operations

Recommendation: 1, page 8

Responsible Organizational Element: JSC, LA14

Recommendation:

"1. In the lifting body flights, the pilots were substantially assisted by calls from the control room where a pilot was available showing the actual location of the vehicle as compared with the planned locations. The Panel is very impressed by both the simplicity and effectiveness of this "modified GCA" in assisting the busy pilot on these short flights. For ALT it is understood that such a plot is planned at Mission Control JSC. It appears prudent to maintain the same plot at DFRC as a backup in the event of the highly unlikely but still possible loss of voice communications between Houston and Edwards. The Panel wonders what penalty the ALT would encounter by including this already available backup system."

Discussion:

We are maintaining the DFRC plot of predicted vs actual ground track.

We plan to use the DFRC plot to track the SCA after separation and as a backup to the Mission Control Center in Houston (MCC-H) in maintaining the real time interface with the FAA for air space clearance.

We do not plan to separate the Orbiter from the SCA without full data and voice communications with the MCC-H. After Orbiter separation, the prime pilot aids for space/time positioning of the Orbiter during free flight are onboard cues (i.e., out the window visual and/or computer guidance and navigation displays). MCC-H assistance to the Orbiter crew after separation is already a backup. All data and voice lines to the MCC-H not only have backup lines and critical coverage by the commercial carriers, but also have diverse routing. The plot boards in the MCC-H are also redundant. Therefore, the use of DFRC vectoring of OV-101 in free flight would have to be considered as a second or third order backup. All primary and backup operations must be covered in training and preflight simulations. Available time and resources do not allow us to include second and third order backups in our operational planning.

Conclusion: Recommend this item be closed.

Subject: ALT Mission Operations

Recommendation: 2, page 8

Responsible Organizational Element: JSC, LA14

Recommendation:

"2. The closest actual experiences to the ALT flights are those that were gained during the lifting body and earlier rocket aircraft flights. We should not overlook any opportunity to use this background wherever appropriate. For example, it is suggested that lifting body pilots be requested to fly the STA and Orbiter simulators and provide comments on their flight experiences. Similarly, it may be useful to have a general critique of ALT mission plans by a group of experienced personnel who have not been involved to date. This group might include such people as Chuck Yeager, Bob White, Bob Rushworth and lifting body engineers of AFFTC."

Discussion:

We intend to use all the expertise available from DFRC to the best advantage of the ALT program. JSC pilots currently have considerably more experience in the specific approaches to be flown in the ALT than do DFRC pilots. However, techniques developed by DFRC in the X-24 and similar programs have proven valuable in attaining this experience.

We have been getting continued input and support from the engineering group at AFFTC and I'm sure you are aware one of our ALT crew commanders is an experienced X-15 pilot.

Conclusion:

Recommend this item be closed.

Subject: ALT Mission Operations

Recommendation: 3, page 9

Responsible Organizational Element: JSC, LA14

Recommendation:

"3. The Panel suggests that crew training might be enhanced by the use of additional existing simulators with capabilities different from simulators now being used. For example, the Air Force simulator (AFFTC Engineering Simulators) at Edwards AFB has proved very valuable for lifting body training. The Air Force simulator is not as comprehensive as other such training devices, but changes in aerodynamic values are easy to accomplish and should be useful in pilot training. Also, interaction between Air Force and NASA personnel would be enhanced."

Discussion:

The AFFTC simulator at Edwards was designed as an engineering tool rather than a crew training simulator. We can't afford the luxury of updating their simulator to the fidelity of the OAS or diverting crew training time to something less than optimum. In addition, we have completed an extensive set of simulations using the AMES simulator which, among other engineering functions, investigated the pilot interaction with the Orbiter handling qualities. Each crew member participated in a minimum of 36 hours each.

Conclusion:

Recommend this item be closed.

Subject: ALT Mission Operations

Recommendation: 4, page 9

Responsible Organizational Element: JSC, LA14

Recommendation:

"4. Experience in lifting body simulator training and missions show that pilots are able to accomplish tasks at a higher rate in the simulator than in actual flights. Use of "fast time" simulators for training is one way of insuring that the pilot is not overburdened in flight. It is recommended that the use of such a simulator be given further consideration."

Discussion:

JSC pioneered the concept of fully qualifying people for flight using only simulation. We have found the use of fast-timing economical as training time in non-time critical flight phases. Real time simulation is essential for time critical flight phases such as the total ALT free flight profile. Results similar to "fast time simulation" are achieved in "real time simulation" through the introduction of system malfunctions during time critical phases.

Conclusion:

Recommend this item be closed.

Recommendation: 1, page 14

Responsible Organizational Element: JSC, MA

Recommendation:

"1. The Panel acknowledges the massive and dedicated effort applied to the avionics system during last year and can only recommend the continued use of the simulators and Orbiter 101 to build up the testing experience the extent of which is the only real verifier of a hardware-software system."

Discussion:

The orbiter project concurs with the recommendation and recognizes that continuing test exposure is required to establish system maturity as well as to verify compliance with requirements. Near capacity utilization of SAIL and ADL for OV-101 avionics testing has been maintained for several months and is projected to continue. Remaining simulation and test activities prior to FAL include:

SAIL - 66 man-in-the-loop (MIL) separation-through-landing runs (with aero variations)

ADL - 72 MIL separation-through-landing runs

OV-101 Captive Flights - Real time observation and post-flight analysis of flight data

OV-101 Combined Systems Test - This is a subset of integrated checkout to be run prior to FAL

Conclusion:

The orbiter project anticipates that the completion of these activities plus testing already completed, will satisfy the intent of the recommendation.

Subject: The Vehicles for ALT

Recommendation: 2, page 14

Responsible Organizational Element: JSC, MA

Recommendation:

"2. If the modified actuator system is not installed in time for the regularly scheduled tests, a special thorough end to end integrated test of the hydraulic system should be required for certification of flightworthiness for ALT."

Discussion:

The recommendation is valid and has been implemented without exception.

As a result of the Orbiter CCB (Configuration Control Board) decision of October 18, 1976, the actuator seals were redesigned and a hydraulic "super reservoir" was added to OV-101. These modifications were made to the vehicle in the November/December 1976 time frame.

The same modifications were made to the FCHL (Flight Control Hydraulics Laboratory) and certification tests were completed. Extensive verification tests have been conducted on OV-101 during the integrated checkout using ground hydraulic power. A comprehensive "APU Hot Fire" test series is in progress for end to end system verification. This test series exercises the complete flight control/hydraulic system and hydraulic systems out tests as well as a complete mission profile run. This test series is scheduled for completion during the week of June 5, 1977. (APU hot fire test successfully completed June 7.)

During the series of "APU Hot Fire" tests, hydraulic fluid was found to be transferring from hydraulic system 1 and 2 to hydraulic system 3. The problem was found to be associated with check valve oscillations (and thus leakage) in the super reservoir system. The inter connects at the super reservoir were capped and the system reverified. Thus the super reservoir is not operative for first captive/active flight. This anomoly is in work and will be closed prior to first free flight.

Conclusion:

The integrated test and checkout program was restructured to include comprehensive end to end certification and verification for flight worthiness of the modified hardware. The intent of the recommendation is being met without exception and the item should be considered closed.

Subject: The Vehicles for ALT

Recommendation: 3, page 15

Responsible Organizational Element: JSC, MA

Recommendation:

"3. Parasitic uses of the main hydraulic power systems are not considered to be acceptable in most modern aircraft practice without careful attention to isolation systems, and should be minimized or eliminated if possible by provision of special power systems before the first free flight of the Orbiter (ALT). It would appear that there are reasonably simple solutions for all such individaul systems (brakes, nose wheel steering, etc.). It is possible that on ALT the reservoir can handle the largest expected leak.

Discussion:

This recommendation has previously been discussed in JSC TWX to MH/ M. S. Malkin, "Status and Closeout of Recommendations of Dr. W. C. Williams' Hydraulic Review," dated May 10, 1977. The present system provides isolation from auxillary equipment through valving. Separate power sources were considered and were not worth the additional weight and complexity. These systems were reassessed during a later review and results presented during the dual tandem actuator briefing, Rockwell Report SSV77-17, on April 1, 1977. OV-102 has reduced the nose and main landing gear uplocks to 1 hydraulic system and utilized pyro thrusters as backup.

Conclusion:

No further changes are considered necessary and this action item is considered closed for ALT.

Subject: The Vehicles for ALT

Recommendation: 4, page 15

Responsible Organizational Element: JSC, MA

Recommendation:

"4. The APU's are on a very tight schedule but their thorough certification must not be short circuited. Further, the Panel suggests serious consideration of a backup source of hydraulic power and added fuel capacity so that starting and stopping of the APU's in active ALT flights are not necessary.

Discussion:

The recommendation expresses a valid concern with regard to APU certification and hot restart during ALT flights. The progress and complete certification program at the APU subcontractor is being closely monitored by both Rockwell/SD and JSC technical personnel. Representatives of both organizations have been on site at the subcontractors since January 1977 throughout the entire certification program. Daily telecons have been held with JSC and Rockwell technical and project office management to maintain close control of the program. The certification program consists of one APU operating in the ITA (integrated test article) for 20 hours, two APU's operating to simulated ALT mission duty cycles for 20 hours each and turbine wheel burst containment tests. Additionally, separate life cycle testing is being conducted at Hydraulic Research on the APU control valve. Potential problems such as the turbine wheel cracks that have been found in certification and production units have been further investigated by special testing as an additional part of certification.

The hot fire APU testing being conducted at DFRC on OV-101 is also being closely monitored by JSC and Rockwell technical personnel. The JSC subsystem manager is on site for these tests. (APU hot fire tests successfully completed June 7.)

The APU restart requirement has been eliminated from the ALT flights. APU No. 1 will be started in flight 30 minutes after 747 brake release. Since present planning for active ALT flights does not require inflight APU restart, a backup hydraulic power source or added fuel capacity is not considered necessary.

Conclussion:

Recommend this item be closed.

Subject: The Vehicles for ALT

Reccommendation: 5, Page 15

Responsible Organizational Element: JSC, EX/MA

Recommendation:

"5. Orbiter software presntly limits control surface movement rate to 20° per second. The Panel recommends that changes in software be considered to permit an increased rate of movement. Experience in the X-15, X-24, YF 16 and B-1 graphically illustrated that flight control problems can result from restrictive rate limits. It is understood that hydraulic system capacity may become a limiting factor for control surface. If simulation with higher rate control surface movement suggests any kind of capacity restraints on the control of the Orbiter an increase of capacity should be considered along with other hydraulic systems modifications now being contemplated."

Discussion:

The orbiter software limits the elevon rate to 20° per second for three or two auxiliary propulsion units (APU's) operating and 10° per second for one APU operating. This limit is necessary to prevent over-demanding of the APU and to allow sufficient flow to other hydraulic users such as the rudder and speedbrake.

Since the elevon function is to trim and control the orbiter in pitch (elevator) and roll (aileron) adequate control surface rate must be provided. The design case occurs in the transonic and subsonic area where the longitudinal stability is minimum, worst case maneuvers are required and turbulence effects are maximum. The flight control system, elevon pitching moment effectiveness, and hydraulic system together provide the intelligence and muscle to maintain control.

The maximum pitch rate of 20° per second was arrived at by extensive analysis and on-line and off-line simulations. This pitch rate has been shown to be adequate to control the vehicle for the automatic and manual control modes at the design flight conditions. Parametric studies of the effect of increased rate have shown no appreciable gain in controllability. The lower maximum rate of 10°/sec. associated with two APU's out has been shown to be adequate although some rate limiting was observed.

Conclusion:

Extensive simulations analysis and management reviews have shown that 20°/sec. is an adequate maximum elevon pitch rate. Potential rate limiting effects will be monitored on all simulations.

Subject: The Vehicles for ALT

Recommendation: 6, page 16

Responsible Organizational Element: JSC, MA

Recommendation:

"6. Ejection seat tests (sled tests) should be completed for velocities up to release speeds before the first manned flight of the Orbiter 101 on the 747."

Discussion:

It was intended to complete the sled test program prior to first manned captive flight, including both the OV101 and OV102 configurations. However, an ejection seat/parachute recontact problem was experienced during the second dynamic test; and the ejection sequence timing was modified to reduce the possibility of recontact. The last two sled tests and remaining hardware were used to successfully verify this sequence change at the ALT flight conditions, including release.

The data from the sled test program is also being analyzed for its applicability to the OFT flight envelope. Should this analysis indicate additional tests are required to provide adequate data for the OFT evaluation, the ejection seats from the completed program can be refurbished and tests conducted in time to support the OV102 program. This analysis should be complete and recommendations for the approach to verification of the OV102 escape system made by July 1977.

Conclusion:

The intent of this recommendation has been met.

Subject: Landing

Subject: The Vehicles for ALT

Recommendation: 7, page 16

Responsible Organizational Element: JSC, MA

Recommendation:

"7. The landing gear system is critical and system ground tests are essential to confidence in the time and certainty of drop. The Panel feels that nose gear shimmy is as critical as extension. Nose gear shimmy will be checked at the contractor and NASA's Langley Research Center before free flight. The program feels a more pressing concern is the completion of the qualification test with static loads and the test of the nose gear door thruster on the simulator. The Panel recommendation is that management review the requirements and results of the certification program."

Discussion:

The Orbiter landing/deceleration system has completed all certification requirements for both FMCF and ALT. The specific safety panel concerns addressed were nose landing gear shimmy, static loads tests on the struts, and nose gear door thruster tests conducted on the landing gear deployment simulator.

The nose landing gear stability (shimmy) tests have been successfully completed at both Bendix, on a dynamometer, and at Langley Research Center on their flat (runway surface) track. All results indicate that the nose gear is very stable, free of shimmy, and capable of damping out artificially induced shimmy.

Both the nose and main landing gear struts have been subjected to all static and dynamic drop test load cases certifying them for ALT. Only two tests remain to be completed on the main gear for OFT static and dynamic load certification. The nose gear has completed OFT static and dynamic load certification conditions, but OFT live axle rolling life tests remain to be completed.

All tests using the nose and main deployment gear simulators have been completed certifying these struts and the NLG pyro thruster for ALT. The OFT deployment simulator tests have not started.

Conclusion:

For ALT the required tests were successfully completed and the gear is certified.

Subject: Vehicles for ALT

Recommendation: 8, Page 16

Responsible Organizational Element: JSC, EX/MA

Recommendation:

"8. The Panel has consistently emphasized that a "tail fairing Off" flight is one of the most persuasive reasons for the ALT program. This test should not be scrubbed for the reason of further need for the 101 vehicle. It should only be scrubbed if it is determined that buffet levels on the 747 are too high for safety and no alternative method of running the test can be devised.

In this respect we again note the fact that the ALT test program is so success oriented that any major problem, causing delay, might well suggest curtailment of ALT. We realize that 101 is to go to Marshall on a tight schedule, but would be concerned if meeting that schedule (or others) resulted in cancellation of tailcone-off flights or the scheduled tailcone-on flights. One step that can be taken is to assure immediate analysis of data after each ALT flight so as to permit rational decisions before the next flight. This may permit consolidation of test objectives on one or more of the tailcone-on flights, thus providing time for tailcone-off flights. Prompt data reduction and analysis will also provide opportunities for the crews to integrate revised procedures in the simulator prior to next flight. The panel understands that JSC is aware of and addressing this need."

Discussion:

All analysis required between flights are being planned with maximum efforts to minimize evaluation time. Tailcone-off flights are a firm program requirement if 747 buffet levels are determined to be acceptable on CA-6.

Conclusion:

The intent of this recommendation is being met.

Subject: Orbiter 102

Observation: 3rd Paragraph, Page 20

Responsible Organizational Element: JSC, EX/MA

Recommendation:

"The JSC Technical Assessment Office has presented an analysis of the control capability for the reentry phase of the mission that shows a sufficiently narrow margin of controllability. The Panel will follow carefully all further analyses and subsonic correlation of flight data. If acrodynamic control margins deteriorate further redesign may need to be considered."

Discussion:

1. JSC is aware of potential controllability problems during entry when the center of gravity extremes are combined with worst on worst aerodynamic variations. These problem areas have received considerable attention through both analysis and simulations. These problems will also be worked in manned simulations planned for August 1977. Extensive off-line simulation work will precede these manned simulations.

2. At the initial OFT center of gravity locations of 66.25% both analysis and simulations indicate adequate control with the aerodynamic variations. However, it is essential that adequate flight test data be obtained during the first few flights to verify the aerodynamic characteristics before the center of gravity is moved from the 66.25% position.

3. A number of Flight Test Requirements (FTR's) have been submitted to obtain test data in these critical regions. Discussions are underway with Flight Operations concerning the validity of these test requirements. If the tests are permitted, sufficient information should be obtained to verify the controllability characteristics of the orbiter. If it is determined that the predicted aerodynamic characteristics are in error by as much as the variations, then either the forward or aft center of gravity boundary may have to be restricted. In all likelihood a restriction on one extreme will result in an expansion at the other extreme. Thus, it is not anticipated that the total center of gravity envelope spread of 2.5% will be significantly reduced of aerodynamic characteristics.

Conclusions:

This item will continue to receive close attention by the appropriate organizations. The FTR documents the problem and is the means by which the protential trim problem will be tracked.

Subject: OV-102

Recommendation: No. 1, page 21

Responsible Organization Element: Orbiter Project Office

Recommendation:

The panel is particularly concerned that the concept of parallel or tandem multiple chamber pistons for elevon actuation be seriously considered for incorporation in the planned modification of the control system. If adoption of such a revised control system should be elected, the design and development program would need to be started immediately.

Discussion:

Triple parallel, tandem and dual parallel actuator concepts have been evaluated for elevon actuation. The triple parallel and dual parallel concepts require major redesign of the wing. The tandem option requires wing structure modification due to the increase in actuator length. The triple parallel and dual parallel concepts have the disadvantage that failure to bypass hydraulically locks the surface, the control management must switch in a new actuator with a failure, and the avionics impacts are somewhat greater than with the tandem concept. Each of the concepts required an increase in hydraulic power for required rates and increased parasitic losses in leakage flow. The tandem concept was selected for further studies since it minimized single point failures and had the least impact to the program.

With a May 1, 1977, ATP, the tandem actuator study schedule shows a schedule impact to OV-102 of 12 weeks. The weight impact is in excess of 800 lbs. The cost impact would be considerable. Due to the disadvantages, the Shuttle Program Office does not plan to incorporate tandem actuators on OV-102. These results have been summarized in a briefing to NASA Headquarters, Mr. J. F. Yardley, on April 1, 1977, and copies can be obtained from them.

With respect to the OV-102 actuators, a "fortress" actuator design has been implemented to eliminate SPF external leakages and minimize internal SPF. Improved design, seals, assembly, and additional testing of hardware is planned to validate these design concepts for 100 mission life with margin. This actuator will be built by the same contractor who builds the SSME and SRB TVC actuators.

Conclusion:

The possibility of incorporating tandem actuators for operational flights remains open. An independent assessment of the Shuttle hydraulic system by MDC is being initiated. This assessment will provide recommendations regarding changes to the hydraulic system for operational vehicles including tandem actuators.

Subject: Orbiter 102

Recommendation: 2, page 21

Responsible Organizational Element: JSC, MA

Recommendation:

"2. The rudder/speed brake actuation system deserves a thorough review for vulnerability to single point failure. For instance, a failure in one of the motors used to position the rudder speed brake could cause an overload on an adjacent motor causing the failure of all the motors in a zipper fashion."

Discussion:

The rudder speed brake and body flap mechanical actuator system has been subjected to intensive design reviews by JSC specialists and support contractors, the Wilkerson Committee and NASA-Hqs. management. For the OV-101, these systems have been adequately qualified and acceptance tested for the ALT program requirements. More specifically, the design problems associated with gear teeth loading, shaft loading, and power-drive-unit pressure pulses have been fixed and certified in the qualification and acceptance test for the ALT mission requirement.

There are, however, some concerns on these actuators for the OV-102 and subsequent operational orbiters related to their total mission requirements which were raised by the various design review teams that are still actively being worked.

References:
1. Rudder Speed Brake and Body Flap Mechanical System Design Assessment SSV 77/7 dated 2-9-77.
2. Rudder Speed Brake and Body Flap Actuation Design Review, Wilkerson Committee Report dated 3-8-77.
3. Follow-up Assessment Report by J. Chamberlin, MDSTC, dated April 1977.
4. Single Failure Point (SSFT Review with J. Yardley on Broken Torque Shaft-Rudder Speed Brake, Body Flap-Hydraulic Motors dated 3-8-77.)
5. Single Failure Point (SSFT) follow-up with J. Yardley on 4-15-77.

Conclusion:

Closeout of these issues are expected prior to, or during, Orbiter 102 Critical Design Review in August 1977. In summary, the issues related to your concern are being addressed and a further report will be given to you at a later date.

Subject: Orbiter 102

Recommendation: 3, page 21

Responsible Organizational Element: JSC, MA

Recommendation:

"3. Increasing the APU fuel capacity on Orbiter 102 should be seriously considered."

Discussion:

The recommendation is not valid based on the present preliminary assessment of the worst OFT mission requirements. The APU fuel tank was an off-the-shelf tank that was utilized on the Orbiter as a cost savings measure rather than develop an optimum size tank for the vehicle mission requirements. The tank capacity at that time was more than 50 percent larger than the worst mission requirement. Best estimates today indicate that although the requirements have grown, the tank is still capable of meeting OV-102 requirements. These present requirements are preliminary and will be further assessed following ALT flight analysis which is currently requiring full attention of the mission planning and analysis personnel. Should it become necessary to enlarge the APU fuel supply, it will also be necessary to enlarge the water boiler water capacity.

Conclusion:

Present best estimates are that APU fuel capacity on OV-102 is adequate. Should more detailed analyses indicate that fuel capacity is insufficient, necessary corrective action will be taken.

SUBJECT: Orbiter 102

RECOMMENDATION: 4, Page 21

RESPONSIBLE ORGANIZATIONAL ELEMENT: JSC-LA2

RECOMMENDATION:

"4. The concept of hydraulic control of the main engines needs a critical review both for the effect on the hydraulic system and to ascertain that the operation of the main engines is not subject to shut down due to "service" system failures when the engine itself is still operable. Inherent in such a reassessment should be a review of the desirability and potential methods for isolating the engine control system after the main engines have fulfilled their function.

DISCUSSION:

1. The Orbiter was originally baselined to have switching valves and a redundant hydraulic supply to each main engine. On December 11, 1974, the Orbiter Configuration Change Board changed the design to the present single string configuration including isolation valves in the supply and return lines. Subsequently, an intensive review was made at Level II, resulting in program requirements change board directive no. S02707, dated July 9, 1976, which concurred with the current configuration and initiated action to expend program resources to improve the basic reliability of the single string concept for the entire Orbiter hydraulic system.

2. During the review of alternative concepts to permit a redundant hydraulic supply for SSME control, various electrical, pressure and flow operated switching/isolation valve options were considered as well as gas/fluid and fluid/fluid motor pump systems. Disadvantages attendant to the above alternatives were the addition of accumulators, increase in software logic, loss of hydraulic pressure to SSME for finite time, additional instrumentation, and/or weight increase. Improper operation of a switching/isolation valve could cause loss of the hydraulic fluid of the redundant hydraulic supply system through the same opening that fluid may have been lost in the primary system, resulting in the loss of two of the three hydraulic systems.

3. In light of the various failures that have occurred during recent APU tests at Sunstrand and in the OV-101 vehicle at DFRC an intensive review was conducted of the decisions and logic cited in paragraphs 1 and 2. As a result of this review, the SSPO PRCB elected to pursue two courses of action. One, to put more effort into improving the design of the fuel pump,

and two, to look again, in detail, at the desirability of developing a simple two-system switching valve that would provide a redundant source of hydraulic power for the SSME control valves. A decision will be made in the near future regarding the correct baseline to pursue with respect to these issues.

4. With reference to the Panel's direct recommendation to review the need for isolation valves to the SSME's after they have fulfilled their mission (launch), a decision was made in July of 1976 to install isolation valves in the SSME supply and return lines, effective on OV 102 and subsequent vehicles including the OV 101 retrofit for orbital flight.

5. An accumulator has been added at the hydraulic system/engine interface to prevent hydraulic system transients from inadvertently shutting down an SSME.

Conclusion:

This item should remain open pending the decision on item 3 and a review of the decision on item 4.

Subject: Orbiter 102

Recommendation: 5, page 22

Responsible Organization Element: JSC, MA.

Recommendation:

"5. The Panel would recommend that the new computer development with the double density memory system be closely monitored so as to assure the maximum compatability with the present hardware and software. This will insure a backlog of experience from ALT to aid in the verification of the software programs for the new computer."

Discussion:

JSC recognized, as did the panel, that the development of the double density memory for the shuttle's general purpose computer required that judicious planning and careful and concerted monitoring of the development process would be necessary to insure that compatability with the present hardware and software would be maximized.

To this end the following actions have been put into effect during the planning, development, manufacturing, and test stages of the double density memory:

1) Utilization of the ALT type or ALT improved type components in the fabrication of the new memory system.

2) Utilization of the ALT mechanical mounting and thermal design.

3) Utilization of the ALT multilayer board technology.

4) Utilization of the ALT automated core mat assembly and acceptance test program.

5) The conducting of detailed design reviews and design audits.

6) The conducting of extensive development testing at the subassembly and assembly level.

7) The conducting of a delta qualification test program to certify for Orbital Flight Test (OFT).

8) The prioritizing of the double-density memory retrofitted general purpose computers to the Software Development Laboratory (SDL) and Avionics Development Laboratories to support early integration and checkout of the OFT software with OFT hardware systems. (This first SDL delivery was accomplished on April 1, 1977.)

In summary, JSC, in recognizing the need for design maturity of the general purpose computers during the OFT development and verification phase, has required that the double density memory system development utilize, to maximum extent possible, the experience and maturity gained during the ALT development process in an attempt to minimize the incompatibility between the new memory and existing hardware and software.

Conclusion:

JSC believes that the plan in process is adequate to fulfill the intent of the recommendation and that the completion of the delta qualification test program will establish the fact that hardware/software compatibility has been fulfilled.

Subject: Orbiter 102

Recommendation: 6, page 22

Responsible Organization Element: JSC, MA

Recommendation:

"6. Currently there is very little experience to predict the behavior of the thermal protection system in hypersonic flow and therefore the system cannot be certified by simularity or analysis. Among the areas that are particularly unpredictable are:

a. The gap configurations in width, its direction with regard to the surface flow.

b. The steps between tile and its tripping influence on the boundary layer into turbulence.

c. Flow in door seal cavities and gaps. There will be a multitude of sub-size tiles interfacing the HRSI with the RCC of the nose-cap and the leading edge segments. These tiles will probably behave differently from the standard size tiles in the airflow. Therefore, the behavior of the patchwork surface and the effects of surface condition, gaps, or steps, etc. still appear to need test exposure to the environment for valid certification."

Discussion:

The first part of the recommendation is not valid. The difficulty lies in the accuracy of extrapolations of aero-thermodynamic data from wind tunnel tests to flight conditions and not in the ability to predict the behavior of the TPS. If the environment is known, then the behavior of the TPS can be accurately determined. The program has adopted the approach of using conservative extrapolations of wind tunnel aero-thermodynamic data to flight conditions in order to provide satisfactory TPS designs. Careful and conservative attention has been paid to tile steps and gaps throughout development. This area is not considered a technical problem by the program.

The remainder of the recommendation having to do with interfacing of tiles with RCC has some validity, but not because of subsize tiles. As recommended, test exposures of interfaces, seals and gaps are planned to certify the designs.

Assessing the influence of hot gas flow through TPS tile gaps, in door seal cavities, and control surface hinge areas is a difficult problem to analytically solve in general because of the 3-dimensional complex geometries and phenomena involved.

Considerable insight into these problems resulted from the elevon cove seal testing performed in the JSC 10MW arc tunnel facility.

Related testing is planned to measure the response of various other seals to simulated thermal, acoustic, and structural loads. These include body flap hinge seal, elevon wing seal, rudder upper edge and seal, interfaces between RCC and RSI, door thermal barriers, RSI gap configurations and gap fillers, pressure gradient effects, etc. Also, system tests of the elevon cove seal and redundant seal are planned.

The influence of gap heating in zero pressure gradient regions is accounted for in the design sizing of the TPS through analysis and correlation of arc jet test data. In areas where there are large pressure gradients, e.g., chine, wing-glove and trailing edges of elevons and body flap, tests are underway and analysis are in preparation to determine the effect of pressure gradients on gap heating and to certify that the designs are satisfactory.

Conclusion:

The planned testing is to confirm that the design approach for tile gap and step as well as seals is satisfaction. If test and analysis indicates a concern then corrective action will be taken.

SUBJECT: Orbiter 102

RECOMMENDATION: 7, Page 22

RESPONSIBLE ORGANIZATION ELEMENT: JSC/LA5

RECOMMENDATION:

"7. The HRSI insulated umbilical doors are exposed to the flight environment on ascent. After separation, the doors will be closed. There is no inspection mode or access planned to assure a proper closure. Consideration should be given to an on-orbit inspection and repair of the TPS and particularly the umbilical door seals to assure a safe entry."

DISCUSSION:

The concern of the panel is valid in terms of TPS and ET umbilical door performance uncertainties. JSC does not question the desirability of eventual EVA capability to perform external vehicle inspection/repair operations and has, therefore, continued to review how we might achieve this technology. As a result, several concepts have developed and are being further reviewed. Among these are:

1. Inflatable EVA translation aids.

2. A free flying maneuverable television system for inspection purposes.

3. Heat resistant materials which might be used for temporary TPS tile damage repairs.

These actions have not, however, eliminated the three main concerns with EVA activities of this type. These are, damage to the TPS as a result of the EVA activities themselves rather than from normal flight loads; the need for penetrations of the TPS and increased mechanisms complexity to allow EVA door closure; and the problems arising from EVA conduct while only two crewmen are on-board during early OFT flights. As a result of these factors, JSC has taken action to assure flight safety in these areas by insuring proper systems performance and providing large design margins. The following actions have been taken in this regard:

a. Increased door structural stiffness to reduce TPS load.

b. Provide dual hinge bearings and actuators to increase door closing forces.

c. Installed a second open door centerline latch to provide large margins over expected ascent loads.

d. Provided a door position indicator to be monitored during door closure.

e. Increased the number of door closed indicator switches.

The ET umbilical door basic design utilizes multiple redundant drive and latch systems, is considerably over designed in terms of expected loads, and has a large degree of failure tolerance.

CONCLUSION:

These actions are believed adequate to satisfy the ASAP flight safety concern on the ET door, and we invite an early ASAP review of the current systems design.

Subject: Orbiter 102

Recommendation: 8, page 23

Responsible Organization Element: JSC, MA

Recommendation:

"8. The currently developed engineering criteria for TPS coating erosion and inspection method should include access feasibility studies."

Discussion:

This recommendation pertains to the inspectability of the TPS between flights, and in particular, the ability to bring men and equipment close enough to perform an effective inspection. Current methods of inspection have proved useful for laboratory operations but require inspector skill, considerable time, and have not been constrained by difficult access. The criteria and methods to perform a practical and effective inspection require development and continued attention as recommendation number 8 discusses.

The present plan is to inspect those TPS tiles after each flight that are potentially exposed to damage (i.e., impact damage, high heating, large panel deflections) before Orbiter is configured for launch.

Conclusion:

This recommendation will be followed.

Subject: Orbiter 102

Recommendation: 9, page 23

Responsible Organization Element: JSC, MA

Recommendation:

"9. The integrity of the aluminum structure after any flight depends on the cooling efficiency of the GSE equipment after landing and the novel design of cooling ducts to prevent the orbiter structure from excessive temperatures. The design and implementation of such a cooling duct system has not yet been certified by a total system test and should be."

Discussion:

Post-landing cooling provides overheat protection basically for electronics and for cabin air but not for any structure. It also provides for humidity and hazardous gas control.

Conclusion:

None of the structure temperature control is dependent upon the cooling system, ducts, or GSE.

"Basic aluminum structure integrity is assured by limiting the backface temperature to 350°F - done by TPS design and entry planning."

Subject: Orbiter 102

Recommendation: 10, page 23

Responsible Organization Element: JSC, MA

Recommendation:

"10. It appears that, as a result of a good reliability history, the mainte[illegible] ance of cabin atmosphere integrity has been based on a "two engine" concept. This has the practical result that any failure will cause the termination of a mission in order to protect the crew from a subsequent single failure. This suggests that systems which must last through the total time of a mission probably should be augmented so that such single failures do not force mission termination for safety."

Discussion:

The above text relates to an early "fail op/fail safe" concept applicable to the Orbiter Air Revitalization Subsystem (ARS). The ARS was subsequently modified (e.g., deletion of one cabin fan) to implement a fail safe philosophy — consistent with other orbiter vehicle subsystems. All critical ARS components are backed by redundant hardware with identical functional capabilities. ARS component life tests as well as integrated systems tests have shown a satisfactory performance history sufficient to assure a safe and successful mission completion.

Conclusion:

The failsafe concept involves only certain highly reliable components. In general, the design includes multiple redundancy. For example, each of the two cabin fans include multiple controls and power supplies. Thus most failures are not "failsafe" only and would not result in a mission termination. The item should be closed based on the overall system adequacy for the intended function.

Subject: Orbiter 102

Recommendation: 11, page 23

Responsible Organization Element: JSC, MA

Recommendation:

"11. The flash evaporator used to supplement radiator cooling is of the "fail safe" variety like the environmental system where a single failure will abort the mission in order to maintain safety. A policy should be considered to insure that such system failures will not abort extensive missions in the name of safety."

Discussion:

A recent modification to the Flash Evaporator Subsystem (FES) controller allows a safe return and entry should either evaporator fail providing the orbiter avionics has been powered down to a "single failure tolerant" configuration. With this change, the FES now provides a minimum fail safe capability. The FES will be tested in the JSC Chamber A beginning December 1977 — followed by integrated tests with the radiator subsystem about September 1978. JSC tests will include FES performance, exhaust duct/nozzle heater sizing, nozzle plume tests, etc. The results of these tests should provide sufficient confidence in the adequacy of the FES heat rejection concept.

Conclusion:

Procedures are being developed which will permit evaluation of failure modes and their impact, if any, on mission continuation.

Subject: Main Engine

Recommendation: 1, page 27

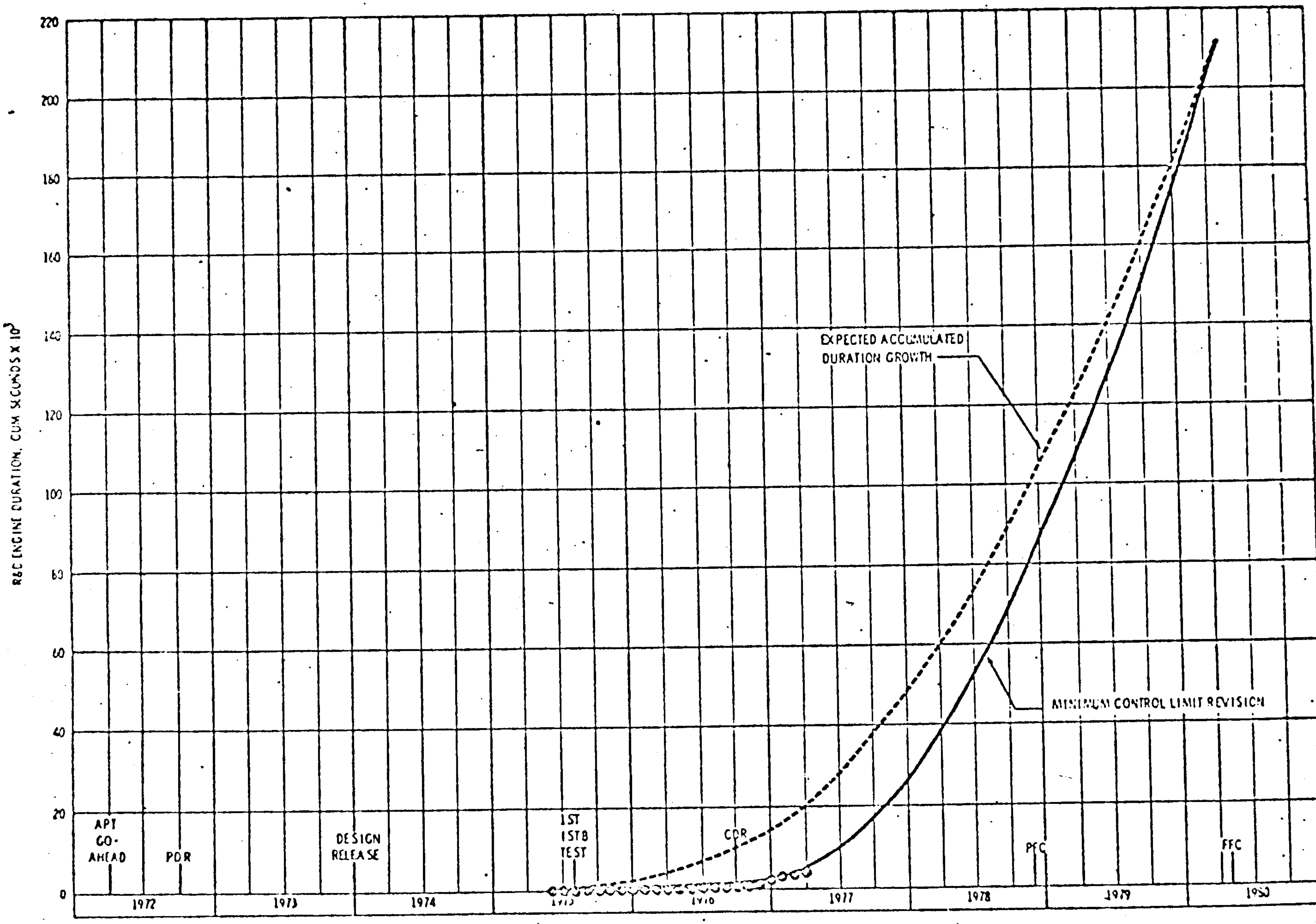
Responsible Organization Element: MSFC, SA51

Recommendation: "1. There are no specific recommendations at this time on resolving the existing problem since the engine development problems are well recognized by the proper levels of management and solutions are being sought and evaluated. However, the deadline is near when sustained engine running time at rated power levels and start transients to all high power levels must be attained if current milestones for major tests and the certification for first orbital flight are to be met. The startup and turbine tip seal problems must be solved quickly so that long-duration runs may be achieved over the range of power levels. Repeatability of performance in meeting test objectives and consistency of performance from engine to engine must be demonstrated within the near term in order to not impact the overall Shuttle schedule."

Discussion: The Panel assessment is accurate and the SSME Project recognizes the need for engine test repeatability and performance consistency demonstration.

Conclusion: The thrust of the assessment is recognized within the SSME Project planning. Progress has been made in resolving the turbomachinery and start transient temperature spike problems that have restricted engine test progress to date and the Project expects test repeatability to improve in the immediate future. The status of overall testing is reported monthly in the Monthly Director's Review as well as other reviews, and the capability of the Project to accomplish the "Accumulated Engine Run Duration" plan (attached) in future months should be tracked as an indicator of progress toward addressing the subject assessment.

ACCUMULATED ENGINE RUN DURATION



CURRENT CUMULATIVE ENGINE DURATION: 4016.71 (THROUGH 3/31/77)

PREDICTED CUMULATIVE ENGINE DURATION AT FFC: 224,000 SECONDS

Subject: Main Engine

Recommendation: 2, page 27

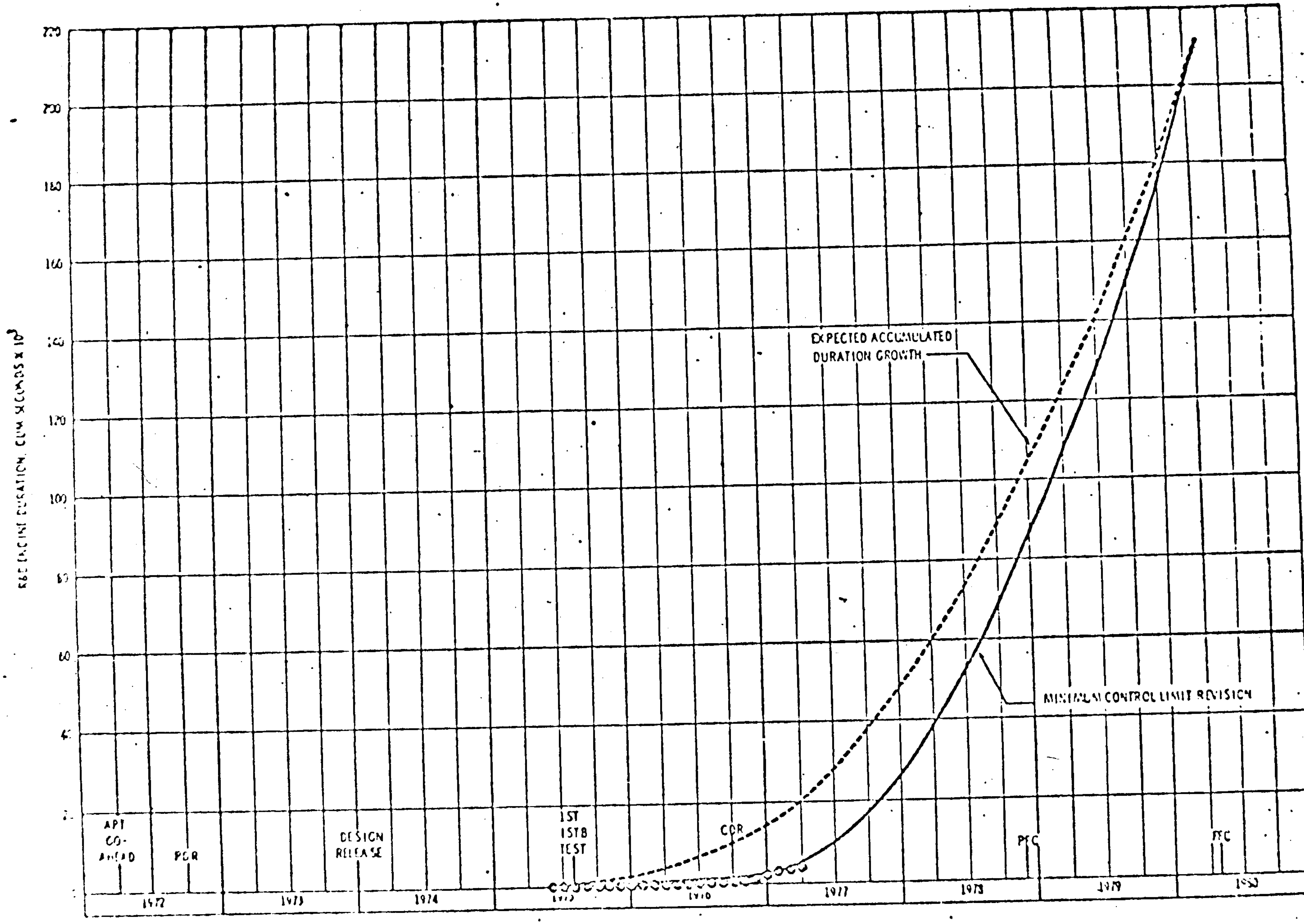
Responsible Organization Element: MSFC, SA51

Recommendation: "2. If these requirements are not met in a timely fashion the program will, of course, face important judgments as to how to guarantee the necessary test time to certify the engines for manned orbital flight. As noted in last year's Annual Report, the planned test program called for fifty-six hours of engine testing in Final Flight Configuration which compares favorably with the test time accumulated on the Saturn F-1 and F-2 engines. Contingency or recovery planning must provide management either the realistic schedule to meet such an objective or the significance of any deviations from that goal in term of the effect on the basis for confidence in the flightreadiness of the engine."

Discussion: The Panel assessment is accurate and the SSME Project is aware of the need for engine maturity demonstration prior to manned flight.

Conclusion: SSME test planning has been adjusted to accomplish the necessary goals prior to First Manned Orbital Flight (FMOF) as well as Final Flight Certification (FFC). An "Accumulated Run Duration" plan (attached) has been established and Project progress is reviewed with MSFC Center Management and Space Shuttle Program Management. In particular, the test progress is reported monthly in the Monthly Director's Review to Dr. Malkin and the progress of the SSME Project against this plan should be used to assess the progress.

ACCUMULATED ENGINE RUN DURATION



C... CUMULATIVE ENGINE DURATION ______ 4016.71 THROUGH 3/01/77

P... CUMULATIVE ENGINE DURATION AT FFC ______ 224,000 SECONDS

SUBJECT: Solid Rocket Booster

RECOMMENDATION: 1, Page 32

RESPONSIBLE ORGANIZATION ELEMENT: JSC-LA2,

RECOMMENDATION:

"1. The SRM, as in other areas of the SRB total assembly, are affected by the system aerothermodynamic loads. These latest data must be factored into the analysis and test as soon as practical to assure proper margins are maintained in the structures and other critical areas."

DISCUSSION:

The aerothermodynamic environment is planned to be updated as the design of the SRB and the ascent flight system dispersion analysis progresses. Recently, the criterion has been revised changing the method of combining variables to be consistent with other ascent analyses and includes an update of the design case thermal environment. The thermal analysis associated with determining the aerothermodynamic loads and thermal protection required is an iterative process that has been through several iterations and will be updated this year to support the SRB Thermal Protection System Critical Design Review.

CONCLUSION:

Any changes in the thermal environment will be factored into the analysis and test to determine if the existing design is adequate and that the proper safety factors are maintained. Any design changes that are made will be reassessed to determine their effect on the aerothermodynamic environment.

Subject: SRB

Recommendation: 2, page 32

Responsibile Organization Element: MSFC, SA41

Recommendation: "2. The nozzle bearing boot, although it has passed some tests, is not out of the woods as yet. There are concerns with regard to assuring that maximum material temperatures are not exceeded during the firing time and that no splits or openings occur allowing hot gas flow inside the bearing."

Discussion: The concern over the nozzle flex bearing flexible boot was and is shared by the SRB Project. The boot has been thickened from an original thickness of 3/4" to 2" through several design iterations.

Conclusion: The concern over the survivability of the flexible protective boot centers around the rate at which the char "sloughs" as the boot is flexed during the vectoring of the nozzle. The first development firing will provide a measure of the loss of protective boot material during the firing. The boot is designed to survive with a safety factor of 2.0. The boot is also instrumented to attempt to measure the material loss rate as a function of time. The item should be closed when development firings have demonstrated an effective protective boot.

Subject: Solid Rocket Booster

Recommendation: 3, page 32

Responsible Organization Element: MSFC, SA41/SRB

Recommendation: "3. The Auxiliary Power Unit has experienced some "under performance" tests which require a reexamination and review to define the manner in which the performance and reliability of these important units can be upgraded."

Discussion: The "under performance" tests of the APU were conducted with deficient fuel pumps. Recent tests with a redesigned fuel pump indicate that performance of the APU is now passing specification values.

Conclusion: The item should remain open until qualification tests of the APU are successfully completed and specification performance demonstrated.

Subject: Solid Rocket Booster

Recommendation: 4, page 32

Responsible Organization Element: MSFC, SA41

Recommendation: "4. The use of the RDX linear shaped charge to sever the aft end of the SRM nozzle is a concern from the viewpoint of premature ignition. The temperatures and their duration would suggest that this item might be classed as a Category 1 hazard and treated accordingly."

Discussion: The SRB Project has some concern about premature ignition and has insulated the charge with sufficient insulation to keep the charge at 100°F well below the auto-ignition temperature of 430°F for RDX.

Conclusion: While the conern is valid, the solution of insulating the charge is straightforward. During ground firings the charge will be instrumented to measure the temperature experienced as the firing progresses. This item will be classed as a Category I hazard until rationale is provided to remove it from this category.

Subject: Solid Rocket Booster

Recommendation: 5, page 33

Responsible Organization Element: MSFC, SA41.

Recommendation: "5. The data returned from the first Orbital Flight Test mission, the first time the total SRB system will be tested as part of a total Shuttle system, will be crucial in defining the margins the SRB makes available to the total system. Since the SRB's must work each and every time, the flight test instrumentation, its location, etc. must be thoughtfully considered. Where transducers are placed into bosses they must be fail-safe. In other words the DFI must not be thought of as simply an "add-on" subsystem."

Discussion: The concern for DFI is shared by the SRB Project. The location and numbers of DFI have been reviewed in detail several times. A recent analysis was made of all DFI located in bosses or other locations where a pressure seal is required. Dual seals are provided and, where possible, a pressure check of those seals is scheduled.

Conclusion: It is recommended that this item be closed on the basis of the above information.

Subject: External Tank

Recommendation: 1., page 35

Responsible Organizational Element: MSFC, SA31

Recommendation: "1. Consideration should be given to contingency planning or success assurance. The spray-on insulation is not expected to be machined over. What then would be done with an application that is too thick for the spec because of a breakdown of a spray gun or blockage of the nozzles."

Discussions:

1. The spray-on foam insulation (SOFI) application parameters and techniques have undergone considerable development and test to insure that the design thickness tolerances can be met. Prior to initial application of the SOFI onto test hardware extensive runs are made on Kraft paper to verify the tooling settings. The complete foam application operation is continuously monitored by a control computer which will shut down the operations if critical limits are exceeded. Manual monitoring of these critical limits is also provided as a backup to the computer.

2. Therefore, it is unlikely that overly thick SOFI will be applied, however, in the event that a malfunction of this nature occurs the TPS application facilities and tooling are configured to permit manual sanding of the "high spots" on a case-by-case basis. Work platforms for access and vacuum systems for dust collection are available.

Should the need for manual sanding become a recurring requirement, with the incident high labor cost, the following contingency planning has been completed.

(a) Development effort has been completed to define the tool design requirements for an automatic machining capability.

(b) The facilities have been built with the capability of adding automatic machining if required.

(c) Automatic machining is currently being used on the feed ducts so cutter technology is available.

Conclusion:

Contingency planning, as recommended, has taken place. A manual repair (sanding) capability exists for an occasional out of tolerance conditions. Only if the cost of the manual repair becomes excessive is it considered feasible to make the investment necessary to implement an automatic machining capability. Activities to date do not show that this cost is justifiable.

It is recommended that this item be closed because contingency planning is in existence.

Subject: ET-Orbiter Separation Interface

Recommendation: 2-Page 36

Responsible Organization Element:

Recommendation:

"2. Additional management control should be considered for the ET-Orbiter interface. There is no plan for a mockup or separation test with a complete hi-fidelity mockup. Another concern that needs additional assessment is the possible damage to the tank caused by the separation dynamic impact loads and subsequent endangering of the Orbiter."

Discussion:

1. The recommendations are valid and have been recognized and planned for or investigated by the program. A detailed presentation covering these recommendations was presented to NASA Headquarters on May 6, 1977.

2. Additional management control should be considered for the ET-Orbiter interface.
The controls established were covered in the May 6, 1977, Headquarters briefing and are considered satisfactory. No management control areas were considered in the resulting actions from Headquarters.

3. There is no plan for a mockup or separation test with a complete hi-fidelity mockup.
A test utilizing a hi-fidelity ET aft interface tool has been added to the program. A study is being conducted to define schedule, test, and cost to add a full-scale Orbiter-ET and ET-SRB separation test with MVGVT. These items were covered in the May 6, 1977, briefing and as actions from Headquarters. Closure of these actions is anticipated for late July 1977.

4. Another concern that needs additional assessment is the possible damage to the tank caused by the separation dynamic impact loads and subsequent endangering of the Orbiter.
This concern was addressed in the May 6, 1977, briefing and the analysis showed the need for an additional test covering ET tank propellant movement at separation. This test has been added to the program.

Conclusion:

It is recommended that this action be closed on the basis of the May 6, 1977, briefing, the added tests, and the resulting actions from NASA Headquarters in accordance with their letter dated May 20, 1977.

Subject: External Tank

Recommendation: 3., Page 36

Responsible Organizational Element: MSFC, SA31

Recommendation "3. Additional effort to determine the adequacy of the present ET/SRB attachment struts may be warranted if present struts do not attenuate pyro separation impact loads. There are no shock absorption devices on the ET-side of the interface."

Discussion:

The recommendation is valid. The MSFC design organization is actively making a design change because loads changes have increased bolt separation loads and require the incorporation of attenuation devices to prevent ET damage from separation shock loads.

The new design for the ET/SRB aft strut is expected to satisfy all safety and engineering requirements for the flight vehicle.

Conclusion: This item should be closed because the design is being changed.

Subject: RISK MANAGEMENT

Recommendation: 1, page 40

Responsible Organization Element: JSC, NA

Recommendation:

1. "The Panel recognizes the accomplishments of both senior program and Safety, Reliability, and Quality Assurance management and their continuing efforts to define and determine aggregate risk in a manner most useful to senior management. The current system provides a great deal of risk information, but the challenge is to assure it is a useful tool for the decision-makers on the Shuttle Program. Mission hazard analyses were made on prior manned space missions to show those safety concerns which would constrain a mission until resolved. In this way they were providing the agregate risk based on the best available information which was examined from objective and subjective viewpoints. The ALT project assessment report has essentially done this as noted by this statement "The JSC Safety Division considers the aggregate risk acceptable, based on the assessment of safety concerns to date, considering the accepted risks and the actions being accomplished to resolve open items." Perhaps what is needed are detailed presentations to management by project and subsystem engineers as well as safety, reliability, and quality assurance engineers so that statements made in mission safety analyses allow management to selectively review the background for specific Shuttle flights."

Discussion:

The suggestion to involve project and subsystem engineers in reliability and safety is endorsed by the program and has been implemented. A detailed review of critical single failure points in the hydraulics system was conducted with the Associate Administrator for Space Flight this past winter. As an indication of the level of detail involved, the reviews were titled landing gear actuator, broken shafts, jammed gear boxes, clogged filters, and jammed spools. In the spring of this year, a review of the FMEA's for all subsystems was conducted by the Program Manager with his subsystem managers making the presentations.

Subject: Risk Management

Recommendation: 3, page 41

Responsible Organizational Element: JSC, LA3

Recommendation:

"3. The effectiveness of configuration management depends upon the implementation of the system as described to the Panel. Therefore, the Panel recommends that audits of the operation of the system continue to be brought to management's attention during this period of development testing, checkout to assure the "as-built" and "as-tested" reflects the "as-designed" systems. This applies to both hardware and software."

Discussion:

Requirements for configuration management audits on the Space Shuttle Program are defined in JSC 07700, Volume IV, Appendix G. The results of the audits conducted to date have been reviewed at the Program Manager's Integration Review (PMIR), a monthly management review chaired by the Program Manager with participation by the key program and project personnel. A detailed review plan and schedule for future audits is currently being developed by JSC-SSPO, LV/Management Systems Office.

Conclusion:

JSC concurs with the Panel's recommendation to continue to conduct audits of the Space Shuttle Program Configuration Management System during DDT&E and present the results of the audits to program management.

Subject: RISK MANAGEMENT

Recommendation: 4, page 42

Responsible Organization Element: JSC, NA

Recommendation:

4. "The Panel agrees with the program investigation that the quality of small electronic parts in the Shuttle is adequate, and would suggest that in the procurement of this class of parts that reliance be placed on the performance specification rather than brand name."

Discussion:

JSC Reliability agrees with the recommendation as stated, but fails to recognize any issue to be resolved. The EEE (electrical, electronic, and electromechanical) parts used on the space shuttle are procured to specifications without regard to brand names. This contractual requirement for specification procurement is very detailed in paragraph 1D301.8 of NHB 5300.4(1D-1), Safety, Reliability, Maintainability, and Quality Provisions for the Space Shuttle Program, which is a portion of all of the space shuttle contracts except for the space shuttle main engine. Further, the design baseline goals of the program are to use JANTXV level semiconductors, level B integrated circuits, next to highest level established reliability resistors and capacitors, and mil-spec level parts for such devices as switches, circuit breakers and relays. These goals are reflected in the Level II Program Definition and Requirements, Volume V, Space Shuttle Program Information Management Requirements.

Conclusion:

The recommendation has been accomplished.

Scheduled for the summer months is a review of the hazards associated with all phases of flight, commencing during the prelaunch count down and conluding with landing. This reivew will be presented by Engineering to management up to the Associate Administrator for Space Flight.

Conclusion:

The Program Manager concerns with the Panel's recommendation and has implemented the desired philosophy of involvement of engineering with safety at the highest levels of management.

Subject: Risk Management

Recommendation: 2, page 41

Responsible Organizational Element: JSC, LA3

Recommendation:

"2. As noted the technical assessment group at JSC is off to a good start and shows that it can make a significant contribution to risk management. Since their continued effectiveness now depends upon the level of support and direct interest by senior program management the Panel makes a point of recommending such personal attention."

Discussion:

The Shuttle Program Assessment Groups have been effective in identifying a number of critical areas in the design and verification of the Shuttle system. Representative items reported are the operation and crew displays for the Orbiter doors covering the ET umbilical receptacles, the adequacy of the Orbiter flash evaporator, and the need for increased emphasis on integrated hardware/software verification planning and management. These issues have been reviewed with the Program Manager and directions for corrective actions have been issued to the contractors. Other issues have also been flagged by the assessment groups, and their recommendations on these issues are presently being reviewed within the program office. A detailed procedure has been established for reviewing and responding to the program assessment reports; however, the complexity of several of the issues assessed has led to special investigations and briefings to the Program Manager. An Assistant to the Manager for Management Integration has been assigned specific responsibility for assuring that a proper and adequate response is made for each assessment report. The progress of these responses is reported at the weekly program status review with the Program Manager.

Conclusion:

The Program Manager agrees with the Panel's recommendation and is giving personal attention to the recommendations from the Program Assessment Groups. Procedures have been established and individuals have been specifically assigned to assure that program assessment reports are investigated and proper actions are taken. The program assessment activity is effective and is continuing.