

DA8/Chairman, Ascent/Entry Flight Techniques Panel

Ascent/Entry Flight Techniques Panel Meeting #11 Minutes

The 11th Ascent/Entry Flight Techniques Panel was held on Monday, May 21, 1984, at JSC. Rockwell, NASA Headquarters, and DFRC participated via teleconference.

#### Summary

- a. The revised thermal analysis for STS 41-D showed no significant concerns.
- b. The STS 41-C braking results were presented, and although the brake damage was the most extensive so far, the braking was still effective. A proposed no-braking DTO to determine the source of the brake damage was disapproved subsequent to the meeting. The recommended braking procedure for STS 41-D is the same as previously.
- c. The MPS LOX ECO timer position and SSME power shutdown levels were reviewed. For stuck SSME failure cases, no early shutdowns were recommended to protect the NPSP (net positive suction pressure).
- d. The gust constraint for the crosswind landing DTO was reviewed in light of weather statistics. The current constraint of 5 knots was found to be unrealistic, and the gust constraint was increased to 8 knots, which allows a landing in a 26 knot wind.
- e. Rockwell presented the results of an analysis of lightning strike effects on LRU's. Most components tested had little or no ill effects from lightning, and those that were adversely affected have adequate recovery or backup procedures.
- f. The autoland DTO systems and trajectory GO/NO GO criteria were reviewed.
- g. The detailed runway priorities for STS 41-D were presented.
- h. If a TAL PASS transition to OPS 3 occurs much below 270K feet or takes longer than 68 seconds, a large velocity error can occur. Since the BFS is not subject to this error, the crew should engage BFS if the transition time or altitude limits are violated.

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#### 1. Thermal Analysis results for STS 41-D - Rockwell

The results of the STS 41-D thermal analysis presented at the last meeting did not incorporate the weight and CG changes caused by the removal of ANIK from the manifest nor the revised roughness factor for OV-103. The analysis was revised to account for these factors, but the results were basically the same as before. There are no significant thermal concerns for STS 41-D.

#### 2. SIS 41-C Brake Results and Recommendations - EK/ME/R. H. Bradley

Mr. Bradley presented the STS 41-C braking results. The landing was on

the lakebed at Edwards. There was no crosswind and the touchdown velocity was somewhat high (214 kts). The total rollout distance was 8,716 feet, with 2,000 feet of that on brakes. The deceleration and brake pressure profiles are shown in enclosure 1. All brakes suffered some damage, with several rotors being broken (see enclosure). The brake damage was worse than on any previous flight, and the reason is still unknown. OV-099 brake damage, since (he brakes were modified, has been worse on the lakebed than on concrete. Roughness and shaking would be worse on the lakebed and could account for the more extensive damage. However, (OV-102 has consistently had less brake damage than OV-099. The reason for this is also unknown. A 360 degree saddle has been installed on the outboard brakes for STS 41-D to help prevent damage. The damage is mostly on the rotor corner lugs at the clips, but it is unknown where the damage starts. E&D has proposed a DTO to not apply the brakes at all on a lakebed landing, to see how much damage the rollout alone causes. This DTO would only be done on the lakebed (normal braking would be used on concrete). If a slight crosswind or another factor requires some Orbiter steering, Mr. Bradley said it was acceptable to pump the upwind brake (except in high speed region 140 knots) in order to prevent the other side from being used. However, if the crosswind is large enough to accomplish the crosswind DTO, this would have priority. There is an open question of whether nosewheel steering should be used to avoid differential braking for this DTO.

Subsequent to this meeting the no-braking DTO was disapproved, and for all landings, E&D still recommends letting the Commander apply brakes as desired, as long as the restrictions on the cue card are observed. The normal procedure, as described at previous flight techniques meetings, should be adhered to if possible.

### 3. APU Ops in Pressurized vs. Depressurized Mode - Rockwell

Canceled

### 4. MPS Lox ECO timer and SSME Shutdown Power Levels - Rockwell/S. Cavenough

Mr. Cavenough presented the SSME NPSP requirements for different power levels since the Lo2 cutoff sensors were moved to the Orbiter feedlines. The sensors were previously located on the ET Lo2 feedline. Except for three engines at 65 percent power level all other combinations of shutdown power levels violated NPSP requirements, including all stuck throttle cases. Early engine shutdown at 23K was investigated for these off nominal cases but the resulting NPSP was less than if no action had been taken. The NPSP is very sensitive to vehicle acceleration and dropped off sharply for all early

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engine shutdowns. Therefore, for stuck SSME failure cases no early shutdowns were recommended to protect NPSP.

### 5. Crosswind Landing DTO Weather Statistics for Gust Constraint - ZS8/S. Raygor

Mr. Raygor presented the weather statistics currently being used for KSC and EDW (enclosure 2). The purpose was to determine the probability of achieving the crosswind landing DTO. The table of winds in the enclosure is from the best statistical model for determining gusts as developed by MSFC, and is applicable to most locations including KSC and EDW. Sample wind stripchart traces are shown in the enclosure. The model uses a gust factor of 0.4 of the average wind, with the peak wind

thus being 14 times the average level. A dashed line of the table shows the limit of gust reporting. Below 5 kts, the deviation is within the noise level of gust readings and gusts become undetectable. The current flight rules permit a maximum crosswind of 20 kts (peak) on the lakebed, including gusts of no more than 5 kts.

According to the KSC and EDW weather measurement statistics, almost any wind with gusts large enough to detect (>5 kts) will violate the gust constraint of the flight rules. The probability of obtaining a crosswind suitable for the DTO is only 1.2 percent. If the gust criteria were changed to 10 kts, which is much more realistic, the probability of achieving conditions for the DTO increases to 15 percent. Based on this, the flight techniques panel is recommending the flight rules be changed to allow gusts of up to 10 kts.

Subsequent to the meeting a compromise with the crew was reached to allow 8 kts for the gust limit and the mission rules have been updated to this limit. This will allow landing in a 26 knot wind without violating the gust rule.

6. STA/Balloon Comparisons - FM5/J. C. Harpold

Deferred

7. S-Band Post-deorbit Burn Data for KSC Landing - FM5/J. C. Harpold

Deferred

8. Lightning Study and Recommendations - Rockwell

Rockwell has completed a study to determine if lightning strikes on the Orbiter can cause any critical logic upsets, i.e., an LRU altering its operating state such that crew and/or vehicle safety is endangered. A summary of the LRU's tested with a 100KA equivalent lightning strike is shown in the table in enclosure 3. High-frequency RF was also introduced into the LRU lines to look for possible upsets. The IMU, RPC, APU controller, and MSBLS showed no reaction to the lightning strikes. The MDM, GPC, DEU, BFC, and MEC LRU's were affected in some way by lightning, the effects and implications of which are summarized in enclosure 3. The worst possible effect on the GPC is a failure to synchronize with a two on two split. Current crew procedures handle this case. The effect on the DEU is to get a critical BITE which loses the ability of the DEIJ to accept input. Real-time recovery procedures are available. A lightning strike can cause the BFS to disengage, but this can be reengaged by the crew. However, since it is doubtful that the crew will even be aware of a

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lightning strike on the Orbiter (T38 crews are often unaware of lightning strikes), they need to be trained to quickly identify a BFS disengagement and recover from it. The IDCA also needs to have the AC bus sensor put in "monitor" whenever a lightning strike is possible. This is currently a real-time ground call, but the nominal entry configuration will be changed to put the AC bus sensor in monitor in the future.

Two items have not been tested by Rockwell - the ASA/ATVC, which is to be tested soon, and the SSME controller, which is under MSFC jurisdiction (they have said it is unaffected by lightning strikes).

9. Runway Redesignate from KSC - FM5/J. C. Harpold

Deferred

10. STS 41-F Autoland Rules and Wave-offs Criteria

a. Systems GO/NO-GO Criteria - DF6/W. Shelton

At a splinter meeting held in April, a basic philosophy was decided upon for developing and implementing the GO/NO GO criteria for the STS 41-F Autoland DTO. Since the auto mode is already verified to 200 feet altitude, it was decided that the autoland testing should be all or nothing to nosewheel touchdown. The decision to go to CSS (manual) would be made at the HAC, or the first rules violation (depending on where it occurs). As a general guideline, autoland will be declared NO GO if a critical system fails down to fail safe. Below 4,000 feet, it is at the discretion of the commander after a systems failure that violates the rules whether to switch to CSS, or maintain the auto mode. Generally, the commander will only switch to CSS below 4,000 feet if a trajectory upset will result from the failure. Enclosure 4 has a summary of the systems failures that would NO GO the autoland DTO .

b. Autoland DTO Trajectory Rules - DH3/B. H. Sweet

The trajectory criteria for the autoland flight rules were reviewed (see enclosure 5). Although the proposed criteria state that autoland is NO GO if the high wind aimpoint is selected, this is not due to a problem with autoland guidance, but is because of crew training (they would not be as familiar with the approach and might not spot slight deviations from the trajectory as quickly). EDW 17 is the only acceptable runway for this DTO, because of the requirements for a lakebed with MLS.

The autoland DTO will be declared NO GO and CSS engaged if autoland guidance has not been initiated or the MLS incorporated by 6000 feet altitude.

11. STS 41-D Detailed Runway Priorities - DH3/B.H. Sweet

The detailed runway priorities are shown in enclosure 6. The priorities for the night and AOA landings are the same as for STS 41-C, and the only change in the nominal EOM priorities is to make EDW prime instead of KSC. This reflects the recent management Policy change. Ball-bars are currently only installed on EDW 17 and 22. The third set was sent to Spain. If a third ball-bar is available, it will be installed on EDW 23.

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All three runways have PAPI's.

12. TAL OPS Transition Problem (Walk-on) - MDTSCO/C. Goodrum

In the nominal TAL sequence, the transition to OPS 3 occurs at about 330K feet altitude, and normally takes 16-20 seconds to load in from mass memory. The OPS 3 entry navigation is initialized with the last OPS 1 nav state updated to the current time. In case of mass memory failures or loading difficulties, up to 68 seconds is allowed for the OPS transition. If not complete by 68 seconds, then the BFS is engaged. From SAIL simulations, a transition to OPS 3 at a lower altitude (266K feet) but nominal transition time caused velocity errors in the nav state of up to 100 feet/second. In Oracle simulations, if a late transition was coupled with the low altitude, a downtrack velocity error of up to 7800 feet/second (worst case) could occur. The error occurs because the Entry Precise Predictor uses an atmosphere model to compute drag, and the atmosphere density model used is

exponentially inaccurate below 270K feet (see enclosure 7), such that the difference between it and the SVDS model at 232K feet is 5,600 percent. This results in an overestimation of the drag, which is integrated into the OPS nav state.

The BFS does not experience this problem because no mass memory access is required, and the nav continues running by integrating at an assumed acceleration. The IMU's are comm faulted while the PASS is in transition, but the IMU HIP outputs constant acceleration. After the PASS transition to OPS 3 is complete, the IMU data are used to partially correct the BFS nav state. Unlike the PASS, the BFS does not use an atmosphere model at these altitudes and is thus a safe backup in case of a large PASS nav error.

A short-term solution to the problem is for the crew to ensure the OPS transition is completed within the 68 seconds. If the transition to OPS 3 is not complete by the cutoff altitude, the BFS should be engaged.

A proposed software fix to the problem is for the PASS to use IMU delta V data across the transition with one step of the super-G integrator instead of relying on an atmosphere model to compute a new nav state. It would also be helpful to incorporate an altitude readout in a BFS display, so that the altitude can be monitored during OPS transition.

T. Cleon Lacefield

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