

DA8/Chairman, Ascent/Entry Flight Techniques Panel

Ascent/Entry Flight Techniques Panel Meeting #13 Minutes

The 13th Ascent/Entry Flight Techniques Panel was held on Thursday, October 25, 1984, at JSC. Rockwell, NASA Headquarters, and DFRC participated via teleconference.

Summary

- a. The STS 51-A launch window on the nominal launch date of November 7 is 18 minutes long. Launch opportunities exist daily to November 11. Although on this latter date, a spacecraft thermal constraint would be violated for a backup deploy, this constraint would be waived.
- b. The STS 51-A abort regions were presented. New throttle levels and AOA targets have closed the TAL gap from 45 to 10 seconds if Moron and Dakar are unavailable.
- c. The STS 51-A landing opportunities and runway selection priorities were presented.
- d. The climatology statistics for STS 51-A KSC and EDW landings were reviewed. Probability for suitable landing weather is fairly good at KSC, and excellent at EDW.
- e. An entry vent door leak analysis was presented. No overpressure would result from fuel or hydrazine leaks, but could from helium or oxidizer leaks. RCS helium leaks require no action, but OMS helium or oxidizer leaks that are detectable by MCC exceed limits and require opening the vent doors. □
The leak levels presented would not be detectable during ascent/entry.
- f. STS 51-A entry communication opportunities were presented. ESTL comm will be requested.
- g. The STS 41-D entry performance analysis was presented, as was a quick first look at the 515 41-& entry performance.
- h. The brake analysis for STS 41-D and STS 41-G were presented. OV103 on STS 41-D had very little damage. OVO99 had extensive damage on the left inboard brake, but performance was not affected.

-1-

1. Launch Window for STS 51-A - DH3/M. F. Collins

The STS 51-A launch window based on ANIK/SYNCOM thermal constraints, and rendezvous constraints is shown in enclosure 1 for launch dates between November 7 and November 11. There are no issues for the planned launch date of November 7. As shown in the daily launch window table in enclosure 1, the total launch window on November 7 is 18 minutes long, which is the length of the rendezvous phasing window. This phasing window falls 37 minutes into the 70 minute yaw steering limit (1000 pounds) window. For a November 11 launch date, the backup deployment opportunity on orbit 49A is below the lower thermal constraint for both spacecraft, but waiver of this limit has been accepted by Telesat (ANIK) and Hughes Communications

(SYNCOM).

2. SIS 51-A Abort Regions - DH3/M. F. Collins

The STS 51-A Cycle 6 ascent abort regions are shown in enclosure 2. These regions reflect the new 67 percent thrust bucket. The 109 percent throttle level moves "press-to-ATO" 20 seconds earlier, and "negative return" 5 seconds earlier. The new AOA shallow targets moves "press-to-ATO" 10 seconds earlier. These changes have recovered 35 of the original 45 seconds TAL gap that exists if Moron and Dakar are unavailable.

3. STS 51-A Landing Opportunities/Runway Selection - DH3/M. F. Collins

The SIS 51-A landing opportunities and runway priorities are shown in enclosure 3;

4. STS Support Wind Profile Radar Status

Deferred

5. Climatology for STS 51-A KSC/EDW - ZS8/G. Hafele

The weather probabilities and average statistics for November at KSC and EDW are shown in enclosure 4. These data indicate a reasonably good chance of being able to land at KSC on the prime landing day. Weather changes fairly rapidly due to front movement during November, so that if weather is unsuitable on the prime day, there is a good chance that the situation will improve on subsequent days. One point in our favor is that the probability of morning fog at KSC in November is low. The weather at EDW is □ likely to be excellent during the STS 51-A landing opportunities.

6. Entry Vent Door Leak Analysis - FS4/R. L. Nieder

Mr. R. Nieder supplied us with leakage numbers for oxidizer leaks in the forward RCS and OMS pods upon which we need to open the vent doors to prevent over pressurization. From his analysis it was determined that no overpressure situation would result from fuel or hydrazine leaks. RCS helium leaks would cause overpressure in 10 seconds and relieve within 30 seconds so no vent door action will be required. The leakage numbers supplied may be detectable during orbit operations, but are not detectable during ascent or entry operations. Any oxidizer leak observed onboard or by the MCC will require the crew to open the vent doors since the detect level

-2-

is above the structural limit leak levels (see enclosure 5). OMS helium leaks also will require the vent doors open. For any question between a helium or oxidizer leak an oxidizer leak will be assumed.Š

Action: 10/25-001 - DF4/R. Lofton and DF6/W. Hale - Submit flight rules changes and procedure changes to support only opening vent doors for oxidizer leaks and OMS helium leaks.

Action: 10/25-002 - DF6/W. Hale - Determine the orbit leak detect level for oxidizer leaks and document in flight rules.

6a. Propellant Leak Rate Analysis from Ground (walk-on) - DF6/N. W. Hale

During entry, MCC can naturally only detect leaks during communication periods (i.e., prior to E1, and from M=12 to M=2.5, where the vent doors are automatically opened). If the crew sees an oxidizer leak, then the maximum

leak rate limit has been exceeded and the crew normally should open the vent doors. Crew isolation of leaks typically takes about 2 minutes in simulations.

7. STS 51-A Entry Communications Opportunities - FM5/B. K. Joosten

The nominal end-of-mission ground track and comm coverage areas are shown in enclosure 6. The nominal end-of-mission crossrange is 626 nmi, and the entry geometry permits comm through TDRS and/or ESTL (JSC). For TDRS comm, the Orbiter antenna geometry would be similar to STS 41-G, with lock-on through the lower antennas at the end of blackout (~ Mach 14). The flight techniques panel concluded that we would like to use ESTL post blackout.

Action: 10/25-003 - DF2/R. P. Moolchan - Determine if ESTL will be available for STS 51-A.

8. STS 41-D Entry Performance - FM5/B. K. Joosten

Mr. Joosten presented the results of the STS 41-D entry analysis (enclosure 7). El was nominal, no significant density or wind shears were encountered during entry, and all eight entry PTI's were executed. The vehicle c.g. appear' to have been close to predicted, as was the RCS propellant usage (see enclosure 7). It is believed that the propellant usage was close to predicted because the transition from laminar to turbulent flow in the Mach 10-12 region was symmetrical. Previous flights had non-symmetrical transitions, which caused differential drag across the Orbiter, with resulting higher RCS activity to maintain lateral control. Indications are that STS 41-G also had a symmetrical flow transition. During entry, the lower surface structural temperature was the highest yet seen (30-50 degrees hotter), even though the entry profile was more benign than most. It is believed this is due to lower surface roughness. On the other hand, the upper surface FRSI areas had the lowest structural temperatures yet encountered (~ 150 degrees cooler on OMS pads, 30 degrees on fuselage).

The TAEM interface state was nominal, but the Orbiter altitude was about 3000 feet below the reference altitude during the heading alignment. This was as much due to an error in the reference altitude as it was to the vehicle being slightly low. The error was caused after the Orbiter entered

-3-

the TACAN cone of confusion and headed directly towards the TACAN, which had a 2 degree bearing error. With no cross vector to compensate for the 2 degree bias, the bearing error was not being updated, which meant that the proper range update was not being input to the reference altitude calculation. As can be seen on page A/E 13-8-12 in enclosure 7, this caused the reference altitude to rise in relation to the actual track. However, as soon as the Orbiter turned on the HAC and a cross track vector was obtained, the onboard computer rapidly updated the nav state and corrected the error.

Although there was no detrimental effect on the landing, the apparent Orbiter altitude error was somewhat disconcerting to the unknowing.

Action: 10/25-004 - DH3/M. F. Collins - Define criteria for determining the tradeoff between TACAN bearing bias and switching to an alternate TACAN site.

A 15-25 knot tailwind was encountered between 20,000 and 10,000 feet, which with the slightly low altitude profile, resulted in the speedbrake being closed in this region. All three TAEM PTI's were executed, although CSS engage (at 45,680 Feet, Mach .88) may have terminated the last one.

During the final approach, the headwind changed to tailwind, which with the shallow outer glide slope, caused the speedbrake to retract early (4000 feet). The landing gear were deployed at 320 feet, and touchdown occurred at 207 KEAS, 2510 feet down the runway. Wheel stop was at 12,785 feet. There was an onboard EAS anomaly near touchdown, which was probably due to a wind gust. The subsonic drag deltas were within the noise level.

9. STS 41-G Entry Performance Quick Look - FM5/B. K. Joosten

Mr. Joosten also presented the STS 41-G preliminary entry analysis, (enclosure 8). Entry had nominal targeting with all 6 entry PTI's executed. A long duration high altitude density shear was encountered from 260K feet to 200K feet. This shear was similar to one encountered on STS-9, and is characteristic of high inclination winter atmospheres (both these flights traveled over cold terrain on a descending node from a high inclination orbit).

The right OMS pod was damaged during entry because of a FRSI strip that was lost during ascent. The damage was extensive enough that the pod had to be replaced and undergo major repair.

The TAEM interface state was nominal, with all four TAEM PTI's executed. Good energy management was maintained through TAEM (CSS engaged at 43,105 feet, Mach 85).

The high wind aimpoint for KSC was used, and the speedbrake was manually retracted at 2500 feet. Gear were deployed about 300 feet, and touchdown occurred at 962 feet (R), 1050 feet (L), and 208 KEAS. Wheel stop was at 11,527 feet.

10. Brakes Status after STS 41-0, STS 41-& (walk-on) - EK/ME/R. H. Bradley

The Orbiter weight and landing conditions were similar for both STS 41-0 and 41-G. There was some light brake damage on STS 41-D (OV108). The left

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-4-

outboard brake (LOB) was completely clean, while the left inboard brake (LIB) had the most chipping in the #4 rotor region on the carbon pad. A few washers were also lost.

On STS 41-G, the Orbiter suffered more damage, but it was characteristic. As a side note, OV-099 (STS 41-G) has consistently suffered more brake damage each flight than the other Orbiters. The LOB was undamaged, but the LIB had washers lost, chipping and cracks in the #4 rotor pad. A few more edges were broken on the brake disks.

To help understand the source of the brake damage, OV-099 was instrumented on STS 41-G to obtain landing and braking data. Brakes were applied at 113 KEAS, and based on the accelerometer and strain gauge data, chatter occurred in the brakes about 1/2 second later, and lasted 3 seconds. Nothing else unusual was detected for the remainder of the roll. Thus the damage probably occurs in the first 3 seconds of brake application, but the analysis to confirm this is not yet complete. The chattering and brake damage appears to be related to the changing coefficient of friction during the brake temperature rise, with a certain coefficient causing cyclic binding and possible resonance with the pad natural frequencies. There is no apparent correlation between vehicle weight, touchdown or brake application speeds, brake pressure, etc., and brake damage. A brake modification (redesign of the clips) is being made starting with STS-51C,

and this will hopefully prevent some of the damage.

T. Cleon Lacefield

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