

DA8-84-24 (FT) May 30, 1984

FROM: DA8/Chairman, Ascent/Entry Flight Techniques

SUBJECT: Ascent/Entry Flight Techniques Panel Meeting #10 Minutes

The tenth Ascent/Entry Flight Techniques Panel was held on Monday, April 30, 1984, at JSC. Rockwell, Headquarters, and DFRC participated via teleconference.

Summary

a. A new deorbit preparation timeline protocol was identified for acceptance which will permit successive deorbit wave-offs on the same day while retaining 2-day waveoff capability. PLBD closure would be moved to T1G -1:50, the STS 41-C cold-soak procedure would be used, and the Orbiter would stay on VRCS.

b. A proposed 482 to define a lower limit of 27 percent OMS quantity needed to perform an OMS dump during contingency aborts was disapproved. Another 482 requiring a RCS +X settling burn for deorbit if OMS quantity <11 percent was approved.

c. A proposal to certify use of an OMS engine with TVC power off was disapproved because of some failures of used no-back actuators that occurred during Rockwell testing and the impact of implementing a screening program.

d. There are no CG or significant thermal concerns for STS 41-D, and either bending filter is acceptable.

e. The STS 41-C entry performance was reviewed, and problems with the STA simulations and wind data correlation were discussed.

f. The STS 41-D ascent abort regions, and OMS 1 and 2 targets were reviewed.

g. Recommended changes were presented to the current vent door configurations during entry to handle any leaks detected. Some flight rule revisions will be submitted.

h. Three recommendations from Rockwell for changing the FCS reconfiguration procedures after failures were accepted.

i. The FDO's proposed that for non-CONUS runways <15000 Feet, the runway would be declared NO GO if after switching to the high-wind aim point, the predicted touchdown point is <=700 feet (instead of the previous 1000 feet). The 1000 feet criteria would still hold for all CONUS runways. An action is pending.

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1. Deorbit Preparation Timeline - DF/J. Knight

§The purpose of this item was to review options that would permit successive deorbit (D/O) wave-offs on the same day while retaining two-day waveoff capability.

On STS-7 entry occurred after two successive wave-offs subsequent to radiator bypass and the vehicle configuration was not changed during that time (i.e., continued to boil water with the FES, remained on PRCS, and

IMU's were not realigned). Such a situation could cause propellant and non-propulsive consumables shortages if the Orbiter has to waveoff for 1 or 2 days. Current propellant and cryogenic consumables budgets are based on waveoff at nominal deorbit TIG, with a reconfiguration until deorbit preparation on the second extension day. IMU alignment at TIG - 2:40 permits 3 sigma drift for the first opportunity only. STS 41-C had a one rev waveoff and modified the current FES use and radiator bypass procedure In order to save RCS.

Mr. Knight presented three options:

- a. Maximum timeline compression (PLBD close at TIG -0:32).
- b. Moderate timeline compression (PLBD close at TIG 1:33).
- c. Increase consumable budgets; leave timeline as is.

Proposed timelines compared with the standard deorbit preparation timeline, and data charts are shown in enclosure 1.

Option A would move PLBD closing to TIG -0:32 and the IMU alignment to TiG -1:30, which is where it was for STS-1 (it was subsequently moved earlier to ease two-man crew workload). The radiator bypass would occur at TiG -1:38. This option has the advantages of using the least water while retaining radiator cold soak for loss of FFS and postlanding capability (allows three opportunities/day for 3 days); delay use of PRCS until OPS 3 transition (TIG -2:00) and does not substantially affect propellant redlines for 2 days with three opportunities/day; allows two successive deorbit opportunities without IMU realignment; and negligible effect on cryogenic redlines. The main disadvantages are that this method is unacceptable when wing glove conditioning is required (this will go away since only OV-102 is affected, and it is being modified at Palmdale); and that moving the IMU alignment closer to TIG does not leave as much time for tracking and could thus increase the navigation state error (of about 1-1 1/2 nmi) at deorbit. It also does not allow time for dealing with door problems.

Option B is similar to option A, but moves the PLBD closure to TIG -1:50 and the radiator bypass to TIG -2:30. With this option the third deorbit opportunity on the third day would be lost due to decreased water production, and one less opportunity per day is available without significantly affecting the propellant redlines.

Option C does not affect the timeline, but is not practical for all flights, since some flights simply cannot carry more consumables. This option would result in deviations from the deorbit preparation timelines.

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A splinter meeting was held and a modified option B was selected. PLBD closure was moved to TIG -1:50 to perform closure before the OPS 3 transition so that the crew would not have to go back to OPS 2 if there was trouble with the doors. Also, instead of doing a pure radiator cold soak, it was proposed to use the radiator temperature high control mode up to FES check-out, just prior to door closing, and stay on the VRCS for propellant savings. This cold soak procedure was used on STS 41-C. The propellant savings for this option is the same as option A (approximately 158 pounds) and the water savings is approximately 100 pounds. The only addition to the crew time line inside of TIG -2:00 is the IMU alignment at TIG -1:30. This allows three opportunities without a star align and two opportunities without an IMU to IMU align for RM.

DF7/R. Y. Wang presented data on radiator capability after a cold soak. Most flights have 16-17 minutes of capability without a waveoff and approximately 14 minutes with a one rev waveoff. This compares very closely with the calculated 12 minute capability on STS 41-C. The effectiveness of the radiator cold soak in any case is a function of many things, including the cargo, the bay temperature and the length of time since the doors have been closed. Data from past flights suggests that the radiators reach equilibrium in 2-3 hours after door closure regardless of their initial temperature.

Action: 04/30-001 - DF6/PROP - Generate the consumables to support the new deorbit preparation timeline proposal.

Action: 04/30-002 - DF7/EECOM - Generate H2O and cryo consumables to support the new deorbit preparation timeline proposal.

Action: 04/30-003 - Deorbit Book Manager - Generate a deorbit timeline incorporating the new deorbit preparation proposals.

Action: 04/30-004 - CB/J. E. Blaha - Determine the acceptability to CB of the compressed deorbit preparation timeline.

Action: 04/30-005 - EECOM - Add another part to the radiator performance DTO to formally test the use of the radiator high control as a cold soak technique for STS 41-F.

Action: 04/30-006 - DF7/EECOM - Reanalyze the loss of FES cases for the proposed radiator cold soak procedure.

2. Propulsion 482's - DF6/M. B. Wortham

a. OMS Dump Quantity Limit

The first 482 reviewed deals with defining a lower limit of OMS quantity necessary to perform an OMS dump during contingency aborts. An RCS settling maneuver (+X translation burn) is required for post-MECO OMS

restart if the pre-MECO dump results in <27 percent propellant remaining in any tank. The concern is to the aft PRCS jets when interconnected during a contingency abort. Helium gas ingestion can occur if the propellant quantity is too low. This could cause the loss of the aft PRCS jets which are needed for entry control A series of 482's were approved which modify procedures by incorporating a RCS burn to meet the settling requirement if the quantity <27

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percent. However, during a contingency (and RTLS contingency) abort, if the dump is not complete before MECO, the dump restarts at MM602, and a settling burn cannot be done in OPS 6, since the THC is not available. This 482 would prevent a dump restart if the quantity <27 percent, by adding a quantity check and decision line to the crew procedures. If the dump is not restarted, the tanks could contain up to 27 percent propellant, which exceeds the tank landing constraint of 22 percent. Rockwell said that they would be willing to waive the landing constraint for the contingency case only if required. There was also some concern about adding to the complexity of already complex procedures. It was decided to resolve this issue in a splinter meeting.

The 482 was subsequently reviewed in a flight techniques splinter meeting. DH3/D. L. Bentley ran several contingency cases in the SMS and

with a full OMS tank could not get to the 27 percent quantity limits prior to MECO. Therefore, this part of the 482 was not approved.

Action: 04/30-007 - DF6/PROP - Provide possible flight software change options that would preclude violation of OMS tank quantity limit(s) for contingency aborts.

b. +X RCS Settling Burns On-orbit

In zero-g operation an OMS quantity <11 percent requires a RCS +X settling burn (flight rule 6-24). This is implemented in the flight data file for a leaking OMS propellant burn, but not for deorbit burns. The settling burn prevents gas ingestion at OMS engine start. The most likely case is a performance (underspeed) AOA. The panel accepted this 482, and the procedure will be added to the cue cards.

3. OMS TVC Fixed Gimbal (Unpowered TVC Burns) - DF6/J. M. Webb

The objective of this presentation was to obtain certification to use an OMS engine with the TVC (thrust vector control) power off. According to current flight rules, an engine is declared failed if the TVC is inoperative, and a next engine fail is cause for entry at the next PLS. However, there are advantages to using an OMS engine locked in the stow position (i.e., without TVC). It is easier to downmode during a burn to RCS from OMS than to OMS from RCS; an OMS engine is more efficient than RCS; it avoids wasting an otherwise good OMS engine; and finally would eliminate an early mission termination. Being able to use a stowed OMS engine requires that the no-back device will hold during an OMS burn with TVC power off (as stated and accepted in a CHIT written for STS-9). If the no-back does not hold and the engine creeps, control could be perturbed to the extent that excessive propellant usage could affect Orbiter safety for entry. The entry targets would be designed to compensate for the off-center thrust vector of a stowed engine, but □ not

for an unknown moving thrust vector. §

Rockwell has tested some qualification and new production no-back actuator units with simulated OMS burn vibrations, and found that although new actuators did not move, some used qualification units did experience creeping. Extensive testing would be required to determine the acceptable lifetime of an actuator before creeping would occur, and even then it would be uncertain how well the results could be applied to a particular Orbiter, since

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inconsistent performance has been experienced between different units. It was thus decided that we cannot approve unpowered TVC OMS burns, because of the uncertainty that the no-back will hold.

4. CG's for STS 41-D - Rockwell/R. Young

The CG's and mass properties for STS 41-D are shown in enclosure 2. There are no CG concerns (either forward or aft) for this flight.

5. STS 41-D Elevon Schedule and Bending Filters Recommendation - Rockwell

The proposed elevon schedule was not presented. Either bending filter is suitable for STS 41-D. The actual filter to be used will be decided according to the recommendation of the entry test experts at a splinter session.

6. Thermal Analysis Results for STS 41-D - Rockwell

Rockwell completed the thermal analysis for STS 41-D, and most of the environment and over-temperature occurrences were the same as accepted for previous flights. However, due to the negative elevon settings, some redesigned TPS insulation is being installed on the aft end of the OMS pods. Although the analysis was completed, it needs to be reworked to account for the new vehicle CG and weight due to the removal of ANIK from the manifest. Also the roughness factor of OV-103 is being revised based on new measurements, and this will have to be factored into the analysis. Despite these changes, Rockwell expects no new thermal concerns. The new analysis should be complete by mid-May, so we will hear the results at the next Ascent/Entry Flight Techniques meeting.

7. STS 41-C Brake Results - EK/ME/R. Bradley

Deferred to next meeting.

8. STS 41-C Entry Performance - FM5/J. Hansen

STS 41-C landed at Edwards runway 17 or rev 108 with a descending/left crossrange of 381 nmi. The landing was originally scheduled for KSC on rev 107, but was changed due to deteriorating weather at KSC. Entry interface, energy and groundtrack were nominal, and no trajectory problems occurred. The descent performance profiles are shown in enclosure 3. Seven of eight entry PTI's were accomplished (PTI-6 was locked out due to Mach 8.7 roll reversal). Two small atmospheric density shears were encountered (see enclosure), the first at Mach 23 (similar to Šone on STS 41-B), and the other at Mach 17-16, the profile of which was disturbed by a roll reversal. As seen in the enclosure, the elevon deflection profile closely followed the schedule. A proposed fix for the 1/4 Hz oscillations problem was incorporated for the first time this flight, and although the relevant data tape has not been analyzed yet, it appears that the oscillations in the region were smaller. The actual effectiveness of the fix might not be determined exactly because there were PRCS jet firings at the time the oscillations occur.

The nominal aimpoint was selected for landing, and touchdown occurred at 1912 feet and 213 knots, with a rollout distance of 8,716 feet (vehicle stop at

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10,628 feet). Because of wind direction shifts, the speedbrake position varied from full open to full close during TAEM. As seen in the wind profile chart in enclosure 3, the TD -6 hours data indicated mostly headwind during approach, while the vehicle actually experienced a strong tailwind, until a large wind direction shear occurred below 1000 feet. This tailwind, and the early retraction of the speedbrake (about 300 feet altitude) contributed to the higher than nominal touchdown speed.

One concern that has surfaced as a result of this flight is that the STA did not respond to tailwinds like the actual vehicle. The STA-predicted touchdown using the nominal aimpoint was 1562 feet and 195 knots (corrected for Edwards), while the actual was 1912 feet and 213 knots (see enclosure 3). The shift in wind direction close to landing seems to indicate the need for wind data and landing conditions closer to touchdown. At EDW the problem was compounded by a failed transponder that prevented obtaining accurate balloon data. If the STA is not entirely accurate in its predictions and landing simulations, as the data seem to now indicate, it is still useful in obtaining changes in

conditions and landing points as touchdown time approaches. However, there are concerns about using the STA closer to landing (e.g., clearing the runway in case of an STA problem). This topic will be considered for a future meeting.

Action: 04/30-008 - CB/J. E. Blaha - Determine if it is acceptable to CB to do the last STA run at about TD -20/25 minutes.

9. STS 41-D Abort Regions and Criteria - MDTSCO/P Pendergrass

The STS 41-D abort regions and ascent issues were reviewed. The nominal throttle bucket has been changed on this flight to a two-step bucket because of loads constraints and resulting launch probability. The nominal throttle bucket is 100 percent/84 percent/65 percent/100 percent (see enclosure 4). With the current adaptive guidance throttling, the 3 sigma cold case bucket is 100 percent/84 percent/75 percent/100 percent, and the 3 sigma hot case is 100 percent/77 percent/65 percent/100 percent. This latter touches the throttle altitude constraint (see enclosure), and a worse than 3 sigma hot SRB could violate the constraint. The maximum deviation we have experienced in flight so far is 1-1 1/2 sigma. The constraint is because of the side loads on the nozzle due to the higher back pressure. §

The SSME's cannot be shut down from abort power level, so K-CO-MAX was changed to 91 percent. Because the sensors were moved, the LOX ECO timers have been reduced for nominal (from 3.398 to 0.478), AOA (1.918 to 0) and RTLS (1.918 to 0). The flight rules and procedures for stuck-on SSME's need to be reevaluated, based on data to be provided by Rockwell. This will be decided at the next Ascent/Entry Flight Techniques Panel.

The STS 41-D abort regions are also shown in enclosure 4

10. STS 41-D OMS 1 and 2 Targets - MDTSCO/L. Drapela

The STS 41-D OMS 1 and 2 targets are shown in the table in enclosure 5. The nominal and delayed targets were designed for a 173.25 nmi circular orbit. The AOA/ATO targets are standard and are the same as used on STS 41-B. Edwards is the prime AOA site (contained in I-loads), and Northrup and KSC

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are backups (OMS-1 in I-loads, OMS-2 are keyed in from cue cards). The chart in enclosure 5 shows the targeting zones for AOA to Edwards or Northrup (it may also be good for KSC). The maximum underspeed for nominal/nominal (shown as 100 in the chart) still has to be determined for this flight. This, should be provided by the FDO's (DH2) by mid-May.

11. Entry Vent Door Leak Analysis Recommendations - FS42/R. L. Nieder

Mr. Nieder was concerned that we were leaving the vent doors open for all APU, OMS, and RCS fuel, oxidizer and helium leaks. He agreed to supply us with the allowable leakage rates below which the doors could be left closed for entry. These numbers will be implemented into the flight rules when received from Mr. Nieder.

Mr. Nieder was also concerned with the flight rule that specifies that if a vent door in the forward or aft bay fails closed, the opposite vent door will remain open for entry. The rule protects against a subsequent vent door failing closed which would result in the loss of the Orbiter. Because of the catastrophic effects of this subsequent failure the damage incurred to the open vent doors was considered acceptable.

Action: 04/30-009 - FS4/R. L. Nieder - Supply the allowable propellant and helium leakages for the forward and aft compartments below which the vent doors can remain closed.

Action: 04-30-010 - DF6/W. H. Gerstenmaier - Show Mr. Nieder where the consumable loading and volume numbers can be found in the ODB.

12. Flight Procedures for FCS Reconfiguration Following Failures - Rockwell

Rockwell suggested several changes to the crew procedures for FCS failures. FCS channel switching causes power interruptions to the ASA's. The result is a bypass of a channel for 900 msec and an erroneous position feedback to RM for 320 msec. The current procedures for bypassed channel failures have the crew place the good channels to override prior to turning a bad channel off which can result in no good channels in control for 900 msec. The new procedure would have the crew turn off the bad channel and sequentially put the channels in override with a 1 second delay between switches. Also no action was recommended after the first failure since there is no history of nuisance trips. All the FCS reconfiguration recommendations were accepted.

The second recommendation was to turn on the ATVC's prior to hydraulic power up. This prevents the SSME from being commanded away from the stow position to the electrical null position due to the TVC isolation valve failure. This recommendation was accepted.

The third recommendation was to place the FCS switches to override, before entry prior to hydraulic power-up until the TVC isolation valves have been opened and closed. For the case where there is a large position error this prevents four channel bypass on a TVC actuator. The GNC's will make this a real-time call if they see a position error large enough to pop the ports.

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Action: 04-30-011 - DF/GNC - Write 482's to cover the FCS reconfiguration and OPS 8 recommendations.

Action: 04-30-012 - DF/GNC - Write a flight rule covering the case where a TVC position error is observed and the FCS switches need to be placed in override to prevent a channel bypass situation. For no data the rule will specify no action.

13. Runway Aimpoint Selection Flight Rule - DH3/G. T. Oliver

The present flight rule on aimpoint selection was expanded to cover non-CONUS runways less than 15 KFT. For these runways the major change was after switching to the high wind aimpoint the runway is no-go if the predicted touchdown point is ≤ 700 feet instead of 1000 feet past the runway threshold. No change from the 1000 feet criteria was made for CONUS concrete or lakebed for the nominal or high wind aimpoints.

Action: 04/30-013 - CB/J. E. Blaha - Determine if this 700 feet criteria at the high wind aimpoint for non conus runways is acceptable to CB.

T. Cleon Lacefield

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