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Lyndon B. Johnson Space Center
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77058

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TO: Distribution

FROM: DA8/Chairman, Ascent/Entry Flight Techniques Panel

SUBJECT: Ascent/Entry Flight Techniques Panel #46 Minutes

The 46th Ascent/Entry Flight Techniques Panel (FTP) meeting was held at JSC on July 22, 1988. Rockwell-Downey and Charles Stark Draper Laboratory participated via teleconference. Any questions or comments should be directed to DA8/R. D. Dittmore at 713-483-5417 or FTS 525-5417. The following items were discussed with the decisions made and actions assigned as noted.

Overall Summary:

a. Action Item Closeout - See Detailed Minutes

b. The pre-mission entry targeting backoff criteria to cover gaps in emergency landing site coverage for highly elliptical, critical missions was reviewed. Design groundrules protect ELS capability by constraining the ellipticity such that a gap no larger than 3 revs exists between landing site opportunities. Shallowing targets and allowing prebank less than or equal to 45 degrees are techniques that will be implemented to maintain an emergency landing capability. Utilizing 90 degree prebank in the pre-mission planning in order to close ELS gap coverage to within 3 revs (Entry FTP #40 recommendation) is not recommended by the Flight Analysis Branch because no recovery prebank exists to account for a deorbit underburn scenario.

For high apogee missions, the affect of prebank on delta V capability is minimal and is a technique that most likely will not help in achieving the desired ELS coverage. However, the Flight Director Office feels that prebank to 90 degrees is an option that should not be ruled out and should be considered on a case-by-case basis as mission criticality warrants.

c. For large crossranges and certain inclinations, a phenomenon exists where guidance downmodes to a "straight-in" approach to the desired landing site even though "overhead" capability remains. A manual "double toggle" item entry procedure resets the "overhead HAC" selection as desired. No checklist changes are required for STS-26. For high inclination missions, the double toggle is required for the TAL landing sites. Additionally, a change to the contingency deorbit procedures will be submitted to incorporate the double toggle action.

d. The abort dump timer development philosophy was reviewed. No issues were identified.

e. Performing deorbit with one PRLA unlatched is acceptable from a loads point-of-view but has not been analyzed with respect to flight control stability during the OMS deorbit burn (-0.016 g's for a 2 engine burn). A full-up stability analysis cannot be completed in order to support STS-26. However, Boeing agreed to provide an estimate of the frequency mode change with a PRLA open to Rockwell-Downey for a "best engineering judgment" review of the frequency sensitivity and resultant flight control stability. This Information Is necessary to determine whether deorbiting with an open PRLA is acceptable.

Flying the entry with the PRLA unlatched is acceptable from both a loads standpoint (as long as negative g's are not experienced) and flight control. DM3/K. D. Walyus presented data showing that 3 sigma auto guidance will not command negative g's. Flight experience also shows that negative g's have not occurred during entry. The FTP agreed that a PRLA unlatched entry was acceptable.

f. The concerns with the FCS channel configuration when the BFS is engaged (discovered during BFS stress testing in SAIL] were addressed. Loss of control has been experienced in the simulators when the BFS is engaged during critical control regimes when two FCS channels have been powered "off". DF6/J. M. Webb presented the concerns and possible solutions at a subsequent splinter meeting where it was determined that current procedures are acceptable for STS-26. Mr. Webb accepted the action to investigate possible software/procedural solutions.

g. Consequences of a 17 inch disconnect valve failing open were again reviewed at the FTP. New analysis incorporating external tank (ET) propellant slosh affects and an improved ET/Orbiter clearance analysis were discussed. Rockwell determined that an LO2 disconnect failure is not a recontact concern. However, recontact can occur under worst case RTLS conditions if an LH2 valve fails full open (late systems RTLS where TAL is not an option). A 3 feet clearance exists for TAL under worst case conditions.

The FTP came to the same conclusion as at the FTP #45 meeting: no procedural or software remedies are required. Clearance exists for the worst case TAL. The worst case RTLS where the ET Is empty at MECO can be avoided by selecting TAL.

Detailed Minutes:

1. Action Item Closeout

88/06/17-001: Closed - Entry control with AA's failed to null is uncertified.

88/06/17-002: Remains open.

88/06-17-003: Closed - The Guidance & Propulsion Systems Branch will propose flight rule requiring a first day PLS for the confirmed loss of

two pitch jets in the same direction, same pod. Entry control with loss of all pitch jets in the same direction, same pod is uncertified.

88/06/17-004: Closed out of board - FMEA/CIL retention rationale implies insight required to detect crossover.

88/06/17-005: Closed - The fuel cell subsystem manager recommends MDF for loss of MDM OF3 as long as the prelaunch diagnostics test is satisfactory, fuel cell life < 1500 hours, and last good data indicated the fuel cell was performing satisfactory.

88/06/17-006: Closed - Rule submitted.

88/06/17-007: Closed - VE4/R. R. Rice confirmed that the airlock is included in the updated Rockwell venting analysis. However, Rockwell has no plans to certify for hatch jettison at 30,000 feet unless Orbiter Project directs the work to be done. A previous certification has already been accomplished for hatch jettison at 20,000 feet. Mr. Rice will ask the aero folks to perform an in-house assessment of hatch jettison between 20K-30K feet in order to backup the existing FDF procedures.

88/06/17-008: Closed - 482 submitted.

88/06/17-009, 10, 11: Remain Open - Rockwell statused action 010 and 011. Action 010 should be ready to discuss by mid-September. Action 011 will be addressed at the August 1988 FTP.

88/02/19-008: Closed - Memorandum has been written and distributed.

88/02/19-005: Closed - Heater duty cycle of 12 minutes "on" and 48 minutes "off" is an acceptable duty cycle for STS-26 and subsequent flights as long as the environment of concern is greater than -5 degree F (no problem for STS-26; subsequent flights have not been analyzed). Rockwell/J. Shafer agreed to assess a 30 percent duty cycle to determine if that particular heater duty cycle would cover the design worst case of -30 F.

88/02/19-006: Closed - Because of cryogenic chilldown affects, APU heater management will be required until approximately 40 hours MET, independent of Orbiter attitude. After 40 hours, the affects of the chilldown are overcome by Orbiter attitude/solar heating. The best attitude to warm the aft compartment and APU feed lines is a top side sun solar inertial attitude. Prior to 40 hours, analysis indicates critical area temperatures to be less than the 35 degree F minimum limit desired in order to preclude APU hydrazine from freezing in the lines. If insight into the APU feed system is lost after 40 hours MET, 5 hours of top side sun is required before temperatures stabilize and manual heater management can be discontinued. Rockwell/J. Shafer also reported that the APU can be considered good, even after manual heater management, through the end of the mission.

2. Max Stretch Capability

Deferred.

3. FRCS Pre-MECO Tank Fail Definition

Deferred.

4. Entry Targeting Techniques-Prepermission Planning - DM3/J. Hansen

Ms. Hansen presented an overview of the entry targeting objectives and constraints, including thermal and skipout concerns, in preparation for discussing the prepermission techniques that the Flight Design and Dynamics Division is willing to utilize in order to provide emergency landing protection. When committing systems dispersions to improve ELS coverage, as far as entry targeting is concerned, the Flight Design and Dynamics Division recommended shallow targeting with up to 45 degree prebank as a prepermission backoff criteria.

The FTP has previously established the maximum acceptable gap between landing opportunities to be 3 revs in order to protect against failures that may require an emergency deorbit. For missions that are highly elliptical, maintaining the ELS gap to within 3 revs may be the constraining design factor. Entry FTP #40 identified dispersions that could be utilized in the design planning to improve the ELS coverage, including shallow targets with up to 90 degrees prebank.

The Flight Design and Dynamics Division does not desire to commit to 90 degrees prebank prepermission for ELS coverage in order to hold back some recovery prebank capability to protect for deorbit underburn cases. The additional capability gained by prebanking for high apogee cases is minimal (20-30 fps). Although for most cases the small gain in delta V capability is not sufficient to "bring In" an ELS to within the 3 rev criteria, the option to prebank to 90 degrees should not be totally ruled out. For specific missions and criticality, prebank of 90 degrees may be an option to consider although low in the "get well" priority list.

5. Entry HAC Selection to Preserve Energy Downmode Options - DM3/M. K. Diogu

Because the overhead HAC is selected and latched after the transition to MM304, a HAC change phenomenon can occur where the straight-in HAC is selected whenever the El orbit groundtrack crosses a projected runway centerline on the great circle. A HAC "wrap up" can occur on the opposite end of the runway with the turn angle at entry/TAEM interface being greater than 360 degrees. Large crossrange and out-of-plane inclination aggravate this phenomenon.

A manual procedural workaround called "double toggle" is available to reselect the desired HAC. The double toggle is simply the act of manually keyboard selecting a straight-in HAC and then reselecting the overhead HAC. Even when a double toggle is not required, performing the procedure does not impact entry.

Mr. Diogu identified the following cases where double toggle will be required:

Inclination Case/Landing Site

- 28.5 Redesignate to Banjul after Ben Guerir abort selected.
- 57 All TAL sites (ZAR, NOR, Ben Guerir, some EOM cases with high crossrange.

The FTP agreed that no change to the FDF was required for STS-26. For subsequent flights, FDF changes will be submitted to cover the above identified cases.

6. IUS Return with One PRLA Open - DM3/K. D. Walyus, EH2/K. L. Lindsay

Two concerns were addressed at the FTP:

a. Flight Control Stability

Once the acceleration exceeds approximately +0.05 g's during entry with one PRLA unlatched, the g-force is sufficient to overcome the IUS "kickoff" springs resulting in the IUS settling down into the notch portion of the PRLA. The load leveler system drives the open PRLA side upward resulting in a system that behaves during entry as if both PRLA's were latched. This configuration is acceptable for entry from a flight control viewpoint.

During the deorbit burn, the flight control stability has not been analyzed for either a two engine (-0.016 g's) or a single OMS engine burn (-0.008 g's). Without the analysis, there is concern that the flight control stability may be affected with one PRLA unlatched as a result of the negative g's imparted by the OMS engines (experience indicates "RCS only" control is acceptable). Actions were accepted by TC2/J. J. Conwell and Rockwell-Downey/FB75/R. G. Epple to provide a recommendation to the FTP on the acceptability of the flight control during the deorbit burn with one PRLA unlatched.

Action 88/07/22-001: TC2/J. J. Conwell - Determine the frequency mode shift associated with one PRLA unlatched during the deorbit burn. Provide the data to Rockwell-Downey/FB75/R. G. Epple.

Action 88/07/22/002: Rockwell-Downey/FB75/R. G. Epple - Determine the impact of the one PRLA unlatched frequency change to the deorbit burn flight control stability. Provide recommendation to the FTP. Due August 26, 1988.

b. IUS Trunnion-to-PRLA Excessive Loads When Subjected to Negative G's

The only load concerns identified during entry with one PRLA unlatched existed when the Orbiter was subjected to negative g's. DM3/K. D. Walyus presented data showing that 3 sigma auto guidance will not command negative g's. Flight experience also shows that negative g's have not occurred during entry (enclosure 1). The FTP agreed that negative g's were unlikely and that the IUS loads associated with entry with one PRLA unlatched were acceptable.

7. Abort Dump Timer Philosophy-Review Design Groundrules - RSOC-R16B/J. P. Vincenti

Mr. Vincenti briefed the FTP on the design groundrules utilized to determine

the abort dump timers for abort dump propellant management (enclosure 2). No issues were Identified.

8. FCS Channel Configuration-BFS Engage Concerns - DF6/J. h. Webb

Mr. Webb briefed the FTP on the concerns associated with BFS engage with two FCS channels powered "off" in response to GPC failures. The concern identified in SAIL BFS stress testing results from the procedural action to power off the affected FCS channel associated with a GPC failure. It was discovered that with two FCS channels powered off (i.e., two GPC failures), a subsequent BFS engage could result in loss of control before the FCS channels could be positioned back to "auto". At engage, the BFS snapshots the bodyflap/rudder/elevon position feedbacks and sets the first commands equal to theme selected feedbacks independent of "goodness". Loss of control was experienced during entry (less than mach 1.5) while elevon hinge moments exceeded 6 million inch-lbf during ascent, prior to SRB separation (spec limit is 1 million inch-lbf).

The only single point failure identified that could result in the above condition is a non-universal I/O failure that could theoretically affect multiple GPC's. Testing in SAIL of the non-universal I/O scenario has revealed that a GPC "fail to sync" is likely to result from this type of failure rather than a redundant set failure (no redundant set failures have been experienced with this failure).

A subsequent splinter meeting discussed the results of SMS testing. First stage concerns are limited to the first 70-80 seconds after which elevon hinge moments upon BFS engage are acceptable. Entry loss of control concerns start at approximately mach 1.5.

Because the window of exposure is so short during ascent and because of the desire to eliminate control transients possible if an FCS channel remains in auto after a GPC failure, the splinter group agreed that the ascent procedural actions are acceptable as written for all subsequent flights (control transients could result in response to environmental/wind conditions with a force fight between good FCS channels and a FCS channel that remains in auto without being commanded by a good GPC). For entry, current procedural actions for loss of 2 GPC's effectively result in the loss of BFS engage capability after mach 1.5 (if the two failed GPC's consist of a combination of GPC's 1, 2, and 3). Mr. Webb accepted an action to assess procedural and/or software options for these scenarios and report back to the FTP.

Action 88/07/22-003: DF6/J. M. Webb - Assess procedural and software solutions to preclude loss of BFS engage capability for the loss of two GPC's where associated FCS channels are powered "off".

9. ET Disconnect Failure Separation Concerns - Rockwell-Downey/FC94/C. W. LaMont

Mr. LaMont briefed the FTP on the updated analysis recently concluded concerning ET/Orbiter recontact concerns during ET SEP should a 17 inch disconnect valve fail open (reference Ascent/Entry FTP #45 minutes). The new study includes ET propellant slosh affects and utilization of a CADCAM program to improve the understanding of ET/Orbiter clearances.

Results of the analysis are as follows:

a. LO2 disconnect failure does not result in recontact, even under the worst case scenario.

b. A 3 foot clearance exists for the worst case TAL where the ET is empty - Exposure to the "empty ET" case is limited to TAL aborts declared at or near the earliest TAL capability. The worst case also assumes the LH2 disconnect valve is failed full open with full flowrate. With nominal residuals the clearance is 11 feet.

c. No recontact for RTLS with nominal residuals - Normally, RTLS guidance targets for 1.6 percent residuals (20,000 lbs) at MECO. With nominal residuals, the RTLS clearance is 28 feet.

d. Recontact is possible for RTLS worst case, empty ET - The empty ET scenario is representative of a late RTLS abort near the loss of RTLS capability. This scenario is remote because of the preference to select TAL abort over RTLS in the overlap region. Normally TAL abort capability is available prior to the region of RTLS concern (empty tank).

Summarizing, separation clearance exists for the worst case TAL. Additionally, the worst case RTLS where the ET is empty at MECO can be avoided by selecting TAL. Based on the very low probability of failure occurrence and the fact that clearance between the ET and the Orbiter is achieved even for the worst case scenarios, the FTP concluded that procedural/software changes are not required to account for a 17 inch disconnect failure.

Ronald D. Dittimore

2 Enclosures