

TO: Distribution
FROM: DA8/Chairman, Ascent/Entry Flight Techniques Panel
SUBJECT: Ascent/Entry Flight Techniques Panel Meeting #53 Minutes

The 53rd Ascent/Entry Flight Techniques Panel (FTP) was held at JSC on January 20, 1989. Rockwell-Downey and MSFC participated via teleconference. Any questions or comments should be directed to DA8/N. W. Hale, Jr. at 713-483-0693 or FTS 525-0693. The following items were discussed with the decisions made and actions assigned as noted.

Overall Summary:

a. The use of hydraulic circulation pumps during powered flight following the failure of an auxiliary power unit is not effective and will not be used.

b. The minimum contingency angle-of-attack used in stretch cases for STS-29 will be 34 degrees.

Detailed Minutes:

1. Action Item Closeout

a. 87/10/30-001: Evaluation of MCC Prediction Capability for Entry S-Turn Requirement to Inhibit RCS Dumps - RSOC/R16D/S. W. Huning

The study concluded that RCS fuel usage for S-turn cases do not exceed the normal (three sigma) allocation with the current 88 second maximum dump time. A reasonable real time predictor of GRTLS S-turn requirement has been developed based on monitoring energy/weight (E/W) vs range-to-go (RGO) at about main engine cutoff (MECO) plus 1 minute. In any case the RCS dump will not be inhibited for high energy. The action is closed.

b. 88/03/25-004: Ascent Abort Case - Moron With Stuck Throttle in the Bucket (28.5 deg); Zaragoza/Moron (57 deg). Investigate the impact of using Moron as the prime TAL site and provide the same type of analysis for a high inclination flight considering Zaragoza or Moron as the prime TAL site - DM3/B. R. Hilty.

The study was performed for 57 degrees with 28.5 degree data promised shortly. The study showed (see enclosure) that with an engine stuck in the bucket, there is an immediate abort gap (no RTLS capability) until very shortly before TAL capability is gained. There is no overlap of RTLS and TAL capability. Therefore, no new to prioritize TAL and RTLS rule is required. The action is closed.

c. 88/09/26-004: Abort Capability with One Engine in Lockup and Another Failing. Determine the capability to reach Ben Guerir, Moron, and Banjul with one engine hydraulically locked up and a second engine failing during the abort leg - RSOC/R16B/T. P. Starkweather.

The study addressed the earliest minimum mixture ratio (5.812) that would cause loss of uphill capability for STS-29. Later mixture ratio shifts would

have to be larger to lose uphill capability and there is considerable question as to whether the engine would continue to run at any larger mixture ratio shift. There is no Moron capability for this situation. Capability to Ben Guerir and Banjul has been significantly reduced. If the earliest abort to Ben Guerir is selected (about 205 seconds) and the good engine subsequently fails prior to 260 seconds, a redesignation to Banjul is required. The action is closed. A significant note is that for mixture ratios of less than 5.7, propellant depletion will occur prior to low level arm, resulting in a catastrophic situation. A splinter meeting will be scheduled to address (1) the situation of Ben Guerir no go for weather (since Moron is normally considered a backup) and (2) operational response to lack of a low level arm with predicted propellant depletion.

d. 88/01/15-004: Elliptical Orbit "Anytime" Deorbit Capability - DM4/C. D. Epp

Deferred to the February FTP.

2. STS-26 and STS-27 Brake Energy Results - ES6/C. C. Campbell

Brake energies for all brakes was less than 20 million foot-pounds. Post ferry flight inspection of the STS-27 brakes showed that one of the back plates was cracked. It is not clear when this occurred and may not have been associated with landing and rollout. Landing deceleration was as high as 14 ft/sec/sec on STS-27 with minimal brakes (brake hydraulic pressures less than 800 psi). An interesting note was that some brake pressures approached 200 psi prior to landing on STS-27 and this is being investigated as possible uncommanded brake pressure. Measurement of the rut depths showed that the good left outboard (LOB) tire rut was about one inch deeper than the leaking left inboard (LIB) tire. The rolling coefficient of friction at nose pitchdown was equivalent to moderate brakes, between 0.2 and 0.3.

3. Low Alpha Capability

a. STS-29 Acceptable Alpha - Include Discussion of Out-of-Plane Abort to Ben Guerir, Moron, Plus In-Plane to Banjul - DM3/B. K. Joosten

Based on preliminary trajectory data, the minimum angle-of-attack (alpha) for STS-29 is 34 degrees. Final determination of the minimum alpha depends on whether the appropriate trajectory profile has been used in the analysis and that will be determined shortly. Heating and erosion of the reinforced carbon carbon (RCC) nose cap and wing leading edges is critical; even momentary piloting dispersions below 34 degrees can lead to failures. Each degree of depression in angle-of-attack during early entry leads to approximately 90 miles greater range capability. Out-of-plane landing sites have reduced heating due to the way in which the crossrange is flown out, however there is reduced ranging capability to those sites.

b. STS-29 Main Engine Limits Boundary-Discuss Delta Time from Droop (Ben Guerir, Moron, Banjul) - DM3/B. K. Joosten

This analysis is not complete and will be presented at a splinter FTP meeting.

c. Lower TAL MECO Altitude - Comparison of External Tank (ET) Hit

Probability Between 360 kft, Post-MECO OMS Burn and 330 kft, With and Without Post-MECO OMS Burn - RI-D/FC94/T. Burk

Currently TAL certification is being performed on a flight by flight basis and no analysis has been performed at the 330 kft MECO altitude in the last several years. Old analysis indicates that increasing the separation altitude delays ET rupture by 50 to 85 seconds. With large ET residuals, an early, violent rupture is more likely to occur. In this case, the hit probability was reduced from 1 in 16,000 to 1 in 100,000 at the 360 kft separation altitude. Data is currently not available on the hit probability with an inoperative tumble valve, but rupture is expected to be earlier with an increased hit probability. Martin Marietta is currently updating their rupture model with flight observed data and will factor that into the analysis.

4. Landing Site Status

a. Review Landing Aid Status and Locations, Surveyed/Not Surveyed (all runways) - DM3/M. G. Linde

All sites are surveyed and the flight software has been audited. The Banjul runway, TACAN, and MLS are misplaced in flight software, however their relative locations are in agreement. The Zaragoza TACAN and MLS are misplaced in flight software and are not in relative alignment with the runway. Software changes have been submitted to correct these errors. The changes will most likely be effective on STS-30; the STS-29 crew has been briefed on these problems.

b. Realtime Landing Aid Reconfiguration - Time Requirement (Xenons, PAPI's, Ball Bar) - DM3/M. G. Linde

Enclosed is a current listing of the landing aids at primary and TAL landing sites. All reconfiguration at Edwards can be accomplished in a timely manner only if there are surveyed sites to install the navigation aids. Moving PAPI's, Ball-Bars and Xenon lights can be accomplished in 1 to 7 hours but only in daylight and only if the lakebed is dry enough to support vehicles (see enclosure).

5. Hydraulic Circulation Pump Operation During Powered Flight

a. Results/Status of Electrical Analysis - RI-D/AC15/B. E. Andrews

The use of a hydraulic circulation (circ) pump was recommended as a way to procedurally work around a two failure scenario where an APU had failed leaving an SSME in hydraulic lockup and then losing pneumatic shutdown on that engine. This was a failure mode brought to light by the failure of a valve actuator prior to STS-26.

Test results showed that if the hydraulic pressure decreased to zero following the APU shutdown and prior to the circ pump actuation, valve drift would cause SSME shutdown. Procedurally, it is considered impossible to prevent very low hydraulic pressure in this case. Turning on the pumps with the APU's active causes the pumps to burn out; so it is not possible to have them in "standby". Automatic circ pump activation was proposed but the hardware and software lead time is significant.

To ensure that electrical bus voltage at the critical interfaces is maintained, new fuel cell launch criteria is required which means that fuel cells will have to be changed out much more frequently. Even then, the SRB interface voltage cannot be maintained. Recently, two other power requirements have been baselined; increasing payload power allotment from 1 to 2.6 kw and adding 3 kw to heat the cryogenic oxygen to meet the increased demand from the crew launch escape suits (LES). These additions make it even more unlikely that circ pumps can be started during ascent without causing severe undervoltage to critical equipment.

The large cost and schedule impacts associated with using the circ pumps in this manner have resulted in the recommendation by RI-D and the Propulsion Systems Integration Group (PSIG) to recommend that the NSTS Program put its resources into improving the MPS valve actuators and/or providing redundant hydraulics. The FTP concurs with this assessment.

b. Electrical Concerns; Fuel Cell Criteria, Consumables Impact - DF7/C. W. Dingell

This study showed that the power transient from starting such a large load would interact with the inductance of the Orbiter wiring to be even lower than other studies; in particular a negative 8 volt margin for 150 milli seconds would occur at the aft power control assemblies (APCA).

c. APU Procedural Implications - Pro's/Con's - DF4/R. C. Doremus

Given the interlock between the APU operate switch and the circ pump operate switch, the minimum time for the crew to get a circ pump running after an APU shutdown is 30 to 45 seconds. As demonstrated in (a) above and (d) below, this is inadequate to prevent SSME shutdown.

d. MPS Valve Drift - Rocketdyne/D. Houseman and MSFC/SA22/E. H. Runkle again showed test data that gives a maximum of four seconds of zero hydraulic pressure with failed pneumatics before the coolant control valve drifted shut enough to cause engine shutdown.

6. OMS/RCS Interconnect ENA vs INH for ATO - If Insufficient Time to Perform Full Dump Non-Interconnected, Does Performance Gain from OMS Engines Counter Performance Impact Associated with Incomplete Dump - DM3/J. V. Turner

Currently, the OMS dump interconnect is configured to the "enable" state for most flights so that the RTLs and TAL dumps would be performed that way. "Inhibit" is advantageous for ATO dumps, so that crew action must be taken in the case of an ATO. It is desirable not to have the crew make a configuration change in a time critical situation. By performing the ATO dump through the OMS engines only (interconnect "inhibited") a gain of about 25 fps in delta velocity capability can be achieved. Only for very small OMS loads can all dumps (RTLs and TAL) be performed non-interconnected (see enclosure). The FTP conclusion is that mixed mode operation should be continued on most flights, with a flight-to-flight evaluation required.

ACTION: 89/01/20-001 - DM3/J. V. Turner - Determine if there is a worst case that will require dump interconnect enable for ATO (e.g., high

altitude, large load, low payload weight).

7. Quantify Benefits Realized from Throttling SSME Back to 65 Percent for Two Engine TAL (performance TAL) - RSOC/R16B/E. R. Johnson

Current crew procedures call for a main engine throttle down to 65 percent on a three engine TAL to allow completion of the OMS propellant dump. It is desirable not to perform this throttle down. Except for extremely small OMS loads, the study shows that it is not possible to eliminate the main engine throttle down on three engine TAL's or late two engine TAL's. The probability of using this procedure is very small based since the throttle back velocity cue occurs only after the press-to-MECO/ATO boundary.

8. STS-30 - DM3/G. L. Norbraten

Deferred to the February FTP.

9. Ascent 2 or 3 Engine-Out Contingency Abort Site Capability - Review Assumptions/Groundrules to be Used to Determine Site Capabilities/Boundaries
- DM3/D. L. Bentley

Assumptions include zero sigma performance dispersion: nominal ascent performance, on-time execution of crew procedures (no decision delays), standard atmosphere, no aerodynamic dispersion, no winds; and contingency abort vehicle constraints including q_{bar} , load factor, hinge moments, etc.

10. Drag Chute Status - ES6/W. R. Acres

Deferred to the February FTP.

11. Status of Contingency Abort Site Work - DM3/D. L. Bentley

For low inclination flights, Bermuda (Kindley NAS) appears to be a possible multiple SSME out emergency landing site. This site covers about a 1 minute window for two simultaneous SSME failures on a 28.5 degree trajectory, and an even longer window for a TAL abort with a subsequent second engine failure. Runway length is marginal at 9694 feet with water at each end (see enclosure). The PRCB has given approval to proceed with the long lead data collection and with the State Department negotiates for emergency landing rights. It is notable that the Bermuda tracking station can "see" the runway, so continuous communication would be available.

Walkon # 12. ET Photography DTO

- a. Separation Analysis and Maneuver Plan - DM3/ B. R. Hilty
Preliminary raw data was presented from which little could be determined other than the general impression that a pitch maneuver only would probably be the best plan. Refinement of the data and final determination of the maneuver will be performed and a splinter meeting of the FTP will consider what the appropriate action should be.

- b. Photography Equipment and Procedures - DF4/M. J. Alexander
MS3 will come up to the flight deck immediately after MECO/ET separation, remove the electro-magnetic interference (EMI) shield from the overhead

windows and retrieve the camera from the A17 locker. The camera will be the Hasselblad which uses 70 mm film; it will be stowed with a 250 mm lens and a 95 exposure magazine installed. The motor drive allows up to 1 frame per second exposure rate. The Hasselblad has no built in exposure meter, but a hand held light meter will also be stowed in the A17 locker.

Note that information on the motion picture camera to film debris through the pilot's window during the first 2 minutes of ascent was not available at the time of the FTP.

Walkon # 13. Contingency Abort Helium Ingestion - DF6/J. E. DeTroye

For some late contingency aborts, the crew must manually start, time, and stop post MECO OMS propellant dumps. If this is not performed correctly, helium from the OMS tanks is ingested into the RCS jets and causes loss of vehicle control in the low dynamic pressure ($qbar$) region of early entry (see enclosure). The manner in which the time is calculated preflight is less than precise and the crew work load is high in these situations.

Alternatively, not performing the dumps leads to very large weight and CG excursions. The FTP was inclined to eliminate the dumps but the Flight Design and Dynamics Division presented a very strong case to perform the dumps even though the window for their use is small and they are contingency cases. A software CR has been proposed to eliminate this problem.

ACTION: 90/01/20-002 - DM3/G. L. Norbraten - Determine an accurate, easy method to preflight calculate the duration of the contingency post-MECO OMS propellant contingency dumps that provides the maximum dump time yet protects the Nz/acceleration angle/OMS tank quantity constraint to prevent helium ingestion into the RCS jets.

Walkon # 14. FRCS Crew Zone Chart Review - RSOC/R16B/M. R. Grabois

A scheme to include the forward RCS capability on the OMS 1/2 targeting crew cue card was described. The FTP decided to make the following changes for STS-30, adopt the proposed new format with the following changes: include the optimum AOA line, add the ATO-SH line, and leave the FRCS off unless the crew office expresses a great desire for that information.

Walkon # 15. Crosswind DTO Rules - DA8/A. L. Briscoe

The proposed changes for the crosswind DTO rules was presented and accepted by the FTP with only editorial changes (see enclosure). A subsequent splinter meeting will address the latest time to redesignate during entry for failure of critical equipment.

The next Ascent/Entry FTP meeting is planned to take place on February 24, 1989, at JSC Building 29 Room 109.

Original Signed By:
N. Wayne Hale, Jr.

Enclosure