

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
Houston, Texas
77058

Reply to Attn of: DA8-88-77 (FT)

September 22, 1988

TO: Distribution
FROM: DA8/Chairman, Ascent/Entry Flight Techniques Panel
SUBJECT: Ascent/Entry Flight Techniques Panel Meeting #48 Minutes

The 48th Ascent/Entry Flight Techniques Panel (FTP) meeting was held at JSC On September 9, 1988. Rockwell-Downey, Charles Stark Draper Laboratory, and Honeywell 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. The forward RCS tank will be used to support ET separation even if the pre-MECO quantity level decreases below 52 percent PVT. The risk of using the FRCS system for ET SEP when the computed propellant quantity decreased to below 52 percent pre-MECO is judged to be less than the risk associated with the "no FRCS ET SEP" procedure.

If the FRCS tank quantity decreased to less than 52 percent pre-MECO and a nominal MECO occurs where time is available to delay ET SEP, ET SEP will be manually delayed to allow rewetting of propellant tank screens. Rockwell-Downey was asked to assess if a jet hot fire procedure could be developed for use while still attached to the ET to clear gas potentially transferred to the aft compartment. However, it is the intention of the FTP to still utilize the FRCS for ET SEP (quantity > 0 percent) until the "no FRCS ET SEP" procedure is certified.

b. Deorbit and entry with one PRLA unlatched is acceptable.

c. IRAMS experience and performance has been acceptable.

d. The ET propellant remaining computation is acceptable as a cue to throttle back the remaining SSME in order to protect NPSP requirements.

e. The real-time data system (RTDS) MEDRIFT program will be utilized to determine the performance shift (mixture ratio, ISP, thrust) resulting from a SSME in hydraulic lockup. When large performance shifts result in loss of uphill capability (i.e., low mixture ratio cases), TAL abort site selection may be delayed in order to allow stabilization of MEDRIFT data output required to assess Orbiter performance capability.

Because Moron capability is lost relatively early, sufficient time to allow the MEDRIFT computation to stabilize may not exist prior to reaching the last

MORON boundary. Because of the uncertainty in the overall performance due to the SSME lockup condition and because aborting to Moron affords little performance margin, Moron may be bypassed even if selected as the prime site in favor of Ben Guerir or Banjul.

Detailed Minutes:

1. Pre-MECO FRCS Tank Fail Definition - Rockwell-Downey/AD56/A. K. Griffith, FC94/C. W. LaMont (88/06/17-009; 88/06/17-011)

The concern with the FRCS tank is the propellant liquid level decreasing below the tank collector screen resulting in a direct helium gas path to the aft compartment and subsequently to the FRCS jets. With gas in the aft compartment, sufficient delta V from the FRCS may not exist to preclude ET/Orbiter recontact during ET separation operations.

Rockwell proposed establishing the tank fail limit at 52 percent propellant quantity remaining based on PVT computations. The 52 percent value guarantees the tank aft compartment is full of liquid and can support mated coast and ET separation requirements. Quantity levels below 52 percent may be an indication that helium gas has been transferred to the aft compartment and may affect ET separation operations.

A geometric relationship between tank vector angle and propellant liquid level was used to define 52 percent as the value at which the collector screen would begin to be uncovered (enclosure 1). The maximum vector angle expected for a nominal ascent profile (independent of inclination) is 14 degrees. The maximum vector angle for a TAL is 16.5 degrees (assumes one SSME failed at 175 seconds, 104 percent throttle). RTLS max vector angle is 14 degrees (worst case is SSME #2 failed at liftoff), ATO/AOA is 15 degrees (SSME failed at 330 seconds), and multiple engine out cases analyzed show the maximum vector angle to be as large as 22 degrees (reference enclosure 2 for relationship between SSME failure and vector angle).

A "no FRCS ET SEP" procedure has been developed and exists in the crew checklists only as a last resort when the FRCS system is not available to support ET separation and no other options exist. Rockwell-Downey had been asked at a previous FTP meeting to make an assessment of the relative risk between using the "no FRCS ET SEP" procedure or accepting the risk and using the FRCS tank below the 52 percent level. Their response at this FTP meeting is to use the procedure for all cases except RTLS (note: the procedure does not work for RTLS).

The FTP did not accept this recommendation. The "no FRCS ET SEP" procedure is an uncertified procedure and is meant only to be used when no other options exist (i.e., no propellant remains in the FRCS). The Orbiter is not designed to account for failure of the FRCS propellant supply system. Additionally, gas ingestion into the aft compartment is not a certain result just because the PVT gaging indicates a propellant quantity below 52 percent (a leak in the tank upper compartment should not affect ET SEP).

It is the judgement of the FTP that the risk associated with using the FRCS system when the computed propellant quantity is less than 52 percent is less than the risk associated with the "no FRCS ET SEP" procedure. Consequently, the FRCS system will be used to support ET separation operations as long as

propellant remains in the tank. For the nominal MECO case where the option exists to delay ET SEP, ET separation will be delayed to allow time for the FRCS propellant to rewet the acquisition screens and minimize helium gas transfer to the aft compartment. Rockwell-Downey was asked to assess if a jet hot fire procedure could be developed for use while still attached to the ET to clear gas potentially transferred to the aft compartment. However, it is the intention of the FTP to still utilize the FRCS for ET separation (quantity > 0%) until the "no FRCS ET SEP" procedure is certified. Actions 88/06/17-009,011 are closed.

Action 88/09/09-001: Rockwell-Downey/FB81/R. F. Zach - Develop procedure for firing FRCS jets while still attached to the ET in order to clear gas potentially trapped in the aft compartment. Provide results to the FTP.

Action 88/09/09-002: Rockwell-Downey/FC94/C. W. LaMont - Assess certification status of the "no FRCS ET SEP" procedure. Determine effort required for certification. Provide results to the FTP.

Action 88/09/09-003: DF6/L. J. Hautzinger - Submit appropriate flight rule and procedural changes to reflect action to delay the nominal ET SEP if the preMECO FRCS quantity < 52 percent.

2. One PRLA Unlatched Acceptability - Rockwell-Downey/FC95/M. M. Nakano (Action 88/07/22-002)

The FTP has previously addressed the concerns associated with one PRLA unlatched during the entry timeframe after the transition to major mode 304 and determined the configuration to be acceptable from both a loads and flight control viewpoint. During the deorbit burn, the flight control stability had not been analyzed for either a two engine or a single OMS engine burn. Rockwell-Downey responded to the action to assess the flight control stability during the deorbit burn and to report the results back to the FTP (ref A/E FTP #46 minutes).

Mr. Nakano reported that no flight control system stability problems were observed for one PRLA unlatched during the deorbit burn. Keel pin deflections are acceptable (enclosure 3). JSC, Boeing, Rockwell, Honeywell, and Draper representatives all agreed. Action 88/07/22-002 is closed.

3. IRAMS Performance (Wet CDDT, FRF) - EH5/M. E. Jones

Mr. Jones reported that the experience with IRAMS to date has been good (wet CDDT, FRF scrub, FRF, V1043-IMU tuned inertial operation, and CDDT). Some problems have existed with the crashing of MASSCOMPS but once the computer has been brought back on-line, evaluation of IMU performance can be continued. The FTP reviewed the data and concurred with Mr. Jones that all IRAMS sites are ready to support STS-26.

4. Accuracy of ET Propellant Remaining Comp Used for NPSP Thottle-back Technique - DM3/D. L. Bentley

Mr. Bentley reported that a reconstruction of STS-3, STS-4, and STS-5 missions revealed only approximately 5,000 lbs error in the accuracy of the

ET propellant remaining computation (5,000 lbs represents approximately 5 ft/sec delta V). The FTP considered the performance impact of plus or minus 5 ft/sec to be acceptable and agreed with Mr. Bentley that the ET propellant remaining computation was an adequate cue for throttle back of the remaining SSME.

5. ARD MEDRIFT Review (walk-on) - DF6/M. R. Jenkins, DM3/C. W. Sparks, Rockwell-Downey/FM81/J. E. Foster

Mr. Jenkins presented an overview of the MEDRIFT MCC program utilized to determine the engine performance shifts as a result of hydraulic lockup. The original MEDRIFT program involved manually inputting affected engine performance characteristics from the MCC displays at 1 minute intervals to arrive at an engine performance impact that would then be passed to the flight dynamics officer (FDO). This method was slow and prone to operator error and performance error since the inputs into the program were singular data points at one minute intervals.

A "new" MEDRIFT program has been developed utilizing the real-time data system (RTDS) capability where data from the Orbiter is automatically input into the MEDRIFT program in "real-time" at 1 sample/second intervals. Engine performance shifts can now be detected earlier and more accurately. This technique will be utilized for STS-26 using an off-line computer hookup (ADS 100). The algorithm will be incorporated into the MOC for STS-27 and subsequent flights.

Mr. Foster presented concerns associated with using the original 5 point manual MEDRIFT technique. Because of weight errors that are introduced into the ARD as a result of engine performance/mixture ratio shifts, the calculated performance boundaries may be adversely affected. Mr. Foster showed that in some instances the ARD predicted TAL capability too early while in other cases the "press uphill" capability would have been predicted too early. The bottom line is that more engine performance points are required in order to insure that the performance boundaries represent available capability. Use of the RTDS MEDRIFT program is a step in the right direction.

Mr. Sparks also addressed the accuracy of the engine performance shift with respect to determining the performance capability available. Because of performance stability questions, the FTP determined that delaying the abort TAL decision is appropriate if BOOSTER determines that the performance information calculated from the RTDS program has not yet stabilized. However, the decision will not be delayed beyond the last opportunity to abort to Ben Guerir when uphill capability is no longer available.

If Moron is the prime abort site (i.e., Ben Guerir is no go due to weather or landing/rollout constraints), because the last capability to abort TAL to Moron comes relatively early, sufficient time to evaluate the hydraulic lockup engine performance may not exist prior to reaching the negative Moron boundary. Because of the time limitation and performance concerns associated with further engine performance degradation, the FTP determined that it is acceptable to press beyond Moron capability and rely upon either Ben Guerir (possible bad weather) or Banjul if uphill capability does not exist. Ben Guerir and Banjul provide larger performance margins than does Moron to account for increased engine performance variations.

For the case where the hydraulically locked up engine performance has not stabilized or cannot be determined to be stable, Ben Guerir may be selected as the prime TAL site even if previously declared "no go" as long as weather/visibility conditions are reasonably acceptable (i.e., minor crosswind violation, minor ceiling violation, minor visibility restriction, etc.). Banjul is another option however more and better information is available concerning the status of Ben Guerir weather/visibility because of the presence of weather balloon data/weather aircraft than is available at Banjul (no weather aircraft no weather balloons). Consequently, Ben Guerir has priority consideration over Banjul even if Ben Guerir is technically "no go".

The FTP also discussed whether or not to assume the next failure to be that of the "good" engine or the "bad" engine. The most conservative approach is to assume the performance boundaries are based on the next failure being a "good" engine such that only one good engine and the affected locked up engine remain available. The boundary call will be delayed based on this assumption. The FTP determined to use this approach and to update the crew on performance capability available should the "bad" engine fail instead of the "good" engine (i.e., better performance capability). Mr. Foster stated that Rockwell is in the process of analyzing the capability available for TAL abort should one engine be stuck in hydraulic lockup and a subsequent "good" engine fails during the abort leg. These data will be presented at a subsequent FTP meeting.

Action 88/09/09-004: Rockwell-Downey/FB81/J. E. Foster, DM4/J. V. West
- 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. Report results to the FTP.

Ronald D. Dittimore

3 Enclosures