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Lyndon B. Johnson Space Center
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TO: Distribution
FROM: DA8/Chairman, Ascent/Entry Flight Techniques Panel
SUBJECT: Ascent/Entry Flight Techniques Panel Meeting #47 Minutes

The 47th Ascent/Entry Flight Techniques Panel (FTP) meeting was held at JSC on August 26, 1988. Rockwell-Downey, Charles tar Draper Laboratory, White Sands Test Facility, 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. Action Item Closeout - See detailed minutes.
- b. Maximum stretch capability (i.e., low alpha) will not be considered in the determination of pre-MECO performance boundaries due to the relative immature status of the technique and associated dispersions.
- c. With only a single SSME remaining, the engine will be throttled back to 65 percent when external tank propellant remaining reaches 1 percent in order to protect single engine 109/104/91 percent NPSP concerns.
- d. Preliminary Ames Test Results:
 1. Single APU entry is acceptable (based on best knowledge of system operation and engineering models).
 2. Crosswind limit of 12 knots is acceptable.
 3. Edwards concrete runway is the best runway for a leaking/flat tire.
 4. Castor nosewheel steering (NWS) if preferred over direct NWS, even for flat tire cases on concrete runways.
- e. FCS checkout part 1 (ASA null fail) can be performed using circ pumps instead of starting an APU.

Detailed Minutes:

1. Action Item Closeout:

88/06/17-009: FRCS Tank Fail Definition - action remains open. Rockwell

agreed to provide a vector angle profile as a function of the ascent trajectory (nominal and 3 sigma), FRCS usage for mated coast and ET SEP (nom and 3 sigma--nominal ascent, TAL, RTLS), plus define/identify the assumptions used in the determination of the vector angle profile. These data will be reviewed on September 9, 1988.

88/06/17-010: Action remains open. To be addressed in mid-September.

88/06/17-011: Action remains open. Scheduled for September 9, 1988.

88/07/22-002: One PRLA failed open. Rockwell stated their effort to review the data. Recommendation will be presented on September 9, 1988. Preliminary results look favorable.

2. Max Stretch Capability - DM3/B. K. Joosten

Mr. Joosten presented the benefits and risks associated with utilizing a lower alpha during the entry phase to increase ranging capability (reference DA8-88-69 (FT) Ascent/Entry Splinter Techniques Minutes, August 12 1988). Drag altimeter accuracy was identified as a possible concern at the splinter meeting but has since been reviewed and deemed acceptable. Additionally, it has been determined that Ben Guerir can be reached using the stretch capability if a Las Palmas guided MECO is obtained.

Mr. Joosten reviewed the agreements made at the splinter meeting to incorporate the max stretch capability into the determination of performance boundaries. Because the magnitude of dispersions associated with manually "flying" the lower alpha have not been determined nor accounted for in the ranging capability, the Flight Design and Dynamics Division recommends not including the stretch gains in the performance boundary calls. With more SES runs and greater experience in the flying techniques and dispersions, incorporating "max stretch" into the boundary calls in the future is a possibility. The FTP accepted the recommendation and encouraged an accelerated effort to understand the dispersions associated with the proposed techniques. The Flight Design and Dynamics Division concurred.

Techniques implemented in response to a second engine failure during a TAL abort to Ben Guerir or Moron were discussed. The following outline is a summary of the techniques to be utilized:

a. Failure of a second engine after the "droop" boundary call (prelaunch determination) will be cause to select the appropriate landing site (i.e., if "droop Amilcar", select Amilcar), pitch up and maintain a "wings level" attitude, and wait until guidance converges.

b. Once guidance converges on the ELS site, an instrumented TAL site should be selected ASAP to determine if guidance will converge on the instrumented site. The high theta attitude should be maintained while waiting for guidance to converge on the instrumented site. Once converged, auto flight control can be re-enabled.

Note: On the Ben Guerir leg, Banjul should be selected after Amilcar convergence. For the Moron leg, Ben Guerir should be selected after Las Palmas convergence.

c. Post-MECO, if guidance never converged to the instrumented site, stretch techniques will be implemented in an attempt to reach the ELS site (Amilcar/Las Palmas).

d. Post-MECO, if guidance converged pre-MECO to the instrumented site, stretch techniques will be utilized in an attempt to reach the instrumented site even at the expense of possibly "over-flying" an ELS than may have been reachable. The FTP concluded that the probability of achieving a successful landing at a non-instrumented ELS site was equal to or less than the bailout survival path. As a result, when in doubt about whether or not the instrumented site can be reached, all attempts will be made to reach the site until it becomes obvious that the required energy is not available.

3. NPSP "throttle-down" Protection Technique - DM3/w. S. Presley

Previous FTP meetings have discussed the concerns associated with inadequate NPSP for single SSME operation (possible uncontained engine damage if insufficient NPSP). Because of these concerns and the lack of testing capability to determine actual NPSP requirements, procedural workarounds were considered.

Mr. Presley briefed the FTP on the option to manually throttle back the remaining engine to 65 percent when the ET propellant reaches 1 percent. Data indicate single engine NPSP requirements can be satisfied with a shutdown from a 65 percent power level. Additionally, exercises in the simulation environment indicated that this option was procedurally doable.

Reviewing the performance impact associated with 65 percent versus 109 percent revealed less than a 30 fps impact to the final cut-off velocity if the throttle down were initiated at 1 percent propellant remaining (enclosure 1). Based on the low performance impact, the fact that the crew has performed and practiced the throttle-back, and that NPSP protection can be realized, the FTP agreed to implement this workaround technique for single SSME remaining cases (109, 104, 91 percent) where a low level cutoff is probable.

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

Deferred.

5. Preliminary Ames Results - CB/J. H. Casper, Rockwell-Downey/FB75/R. G. Epple

Ames testing included evaluation of single APU capability, flat tire effects, tire wear on KSC surface, drag chute, and redundant NWS. It is important to note that the Ames configuration has changed since the last testing conducted in 1987. The capability now exists to have approximately 4 feet of travel in the X direction with the cab configured for Y-axis travel. Additionally, the hexapod configuration has been changed to a new four axis motion generator resulting in a more realistic motion environment.

Single APU:

No cases tested resulted in loss of control although pilot workload was high under certain worst case crosswind and turbulence conditions. This compares

to the last time single APU capability was evaluated at Ames (early 1980) where loss of control resulted approximately 35 percent of the time with crosswinds greater than 10 kts and 10 percent of the time with crosswinds restricted to less than 10 kts. The addition of a HUD, smart speedbrake logic, more standard landing techniques, and Ames computer generated visuals versus the old camera/model board projection technique are felt to be the main reasons for the improved results (the visuals may be the most dramatic improvement because the old system introduced time delays into the visual evaluation that could have easily resulted in increased PIO's and loss of control).

Varying Orbiter weight, cg, and environment winds/turbulence were tested from 10,000 feet altitude through touchdown (Rockwell-Downey concurred that no single APU concerns exist above 10,000 feet). Different runways (lakebed vs concrete) were also reviewed for acceptability (enclosure 2). It should be noted that in all the evaluations, it is assumed that the hydraulic system can supply the aerosurface rates subject to PRL restrictions. Rockwell-Downey was asked to confirm their continued support of this assumption since PRL constraints were originally developed with hydraulic demand limitations in mind. General results/trends observed are identified below.

a. No loss of control although some cases approached derotation rate constraints.

b. Some rate limiting (elevation/aileron) occurs just prior to touchdown and significant rate limiting (elevation) occurs during derotation.

c. Derotation rate is largest area of concern; heavy weight Orbiter with forward cg resulted in larger derotation rates.

d. Increases in turbulence/crosswind resulted in greater pilot workload and larger derotation rates (headwind was also a factor but requires further data review to determine whether or not a headwind placard should be implemented).

e. Concrete runways produce lower derotation rates.

f. Recommended pilot techniques include minimizing control stick inputs as much as possible, landing 5-10 kts fast, and derotating 10 kts early to minimize elevation rate limiting.

Action 88/08/26-001: Rockwell-Downey/FB81/R. F. Zach - Confirm the assumption that a single hydraulic system can supply the aerosurface PRL demand. Report results back to the FTP.

Best runway for leaking/flat tire:

Unknowns associated with the dragging strut coefficient of friction and the lakebed coefficient of rolling friction contribute to the dilemma associated with selecting the best runway for a leaking/flat tire. Consequences of tire/wheel failure and resultant tire fragments/shrapnel damage are unknown and must also be considered.

Recent Ames testing compared landing with a flat tire on Edwards lakebed, Northrup lakebed, Edwards concrete, and KSC using the best information

available for dragging strut and rolling coefficients of friction. Results indicate that the concrete runway is preferred for the following reasons:

- a. Two to 4 deg/sec lower nosewheel slapdown.
- b. Lower drag and side loads on the main gear strut.
- c. Better Cooper-Harper handling quality ratings.
- d. Half the lateral drift during tire failures.

Based on this data, the Astronaut Office recommends selecting Edwards concrete as the preferred runway for a leaking/flat tire. Northrup is recommended as the second choice with KSC and Edwards lakebed in following order.

Rockwell agreed with Edwards concrete as the first priority but recommended that KSC be next in priority in order to eliminate the unknowns associated with lakebed hardness and dragging strut coefficient of friction.

The FTP accepted the Astronaut Office recommendation, selecting Northrup above KSC (#2 and #3) because of the knowledge that Northrup is significantly harder than the Edwards lakebed and the lateral margin available at Northrup should the Orbiter leave the runway is significantly greater than at KSC.

Crosswind Limits:

Ames testing confirmed that the 12 kt crosswind rule is acceptable with all systems operating normally (handling qualities were generally level I). However, for a flat downwind tire, it was noted that GPC NWS could not always handle the failure in the presence of a 12 kt crosswind (tendency to over control). CB/J. H. Casper suggested that training on the Ames VMS may be the only solution to the downwind tire fail scenario. No rule changes were recommended. DM3/B. R. Hilty accepted the action to submit a flight rules format change to allow a separate crosswind limit for tire failure (similar to the APU exception) should further testing indicate a lower crosswind limit is required for tire failures.

Nosewheel Steering:

As noted at previous Ames sessions, direct NWS is extremely sensitive due to the lack of acceleration feedback. The latest set of Ames tests show that 90 percent of the pilots over controlled and ran off the runway using direct NWS with 12 kts crosswind on an RTLS. As a result, pilot opinion is nearly unanimous that castor NWS should be selected rather than direct with GPC NWS not available. The FTP accepted the Astronaut Office recommendation. Flight rules will be modified accordingly.

Drag Chute:

The technique of when to deploy the chute after touchdown was addressed. If deployed too soon after main gear touchdown, skipping can occur (40 ft chute, reefed or unreefed). Additionally, there exists a tendency to delay the derotation if the drag chute is deployed at main gear touchdown resulting in a harder slapdown on the nosegear. Techniques will have to be developed to

address the above concerns.

Improved NWS:

Manual switching for redundant GPC NWS is acceptable.

6. FCS Checkout Philosophy with APU Failures (walk-on) - DF6/S. J. Elsner, DF4/A. Bachik

Existing flight rules prohibit starting an APU for the on-orbit FCS checkout if an APU has previously been declared failed. The Entry FTP addressed this concern in 1987 and determined that performing the FCS checkout to detect ASA null failures in the timeframe between deorbit and entry interface is acceptable should an APU be declared failed during orbit ops. Mr. Elsner briefed the FTP on the possibility of using the circ pumps during on-orbit operations to provide sufficient hydraulic pressure to allow the ASA null check to be performed prior to the deorbit burn.

After reviewing previous flight data, Mr. Elsner determined that the circ pumps are an acceptable alternative to starting an APU in order to accomplish the ASA null driver check. Mr. Bachik concurred.

The FTP agreed that the circ pumps were a viable option to starting an APU and asked the Guidance & Propulsion Systems Branch to submit flight rules changes and initiate FDF procedures to accomplish the ASA null checkout using only the circ pumps. A discussion followed concerning whether or not using circ pumps to perform the ASA null checkout should be the normal way of doing business instead of starting an APU. This would eliminate one start on an entry critical APU and reduce the probability of a failure (i.e., the most likely failure is when the APU is running). DF6/J. W. Bantle agreed to review the justification from a GNC point of view as to why an APU start was required in order to perform FCS checkout part I (i.e., more than just ASA null checkout). The FTP will address this subject in the near future.

Action 88/08/26-002: DF6/S. J. Elsner - Submit appropriate flight rule and FDF changes to allow the ASA null checkout to be performed using only the circ pumps.

Action 88/08/26-003: DF4/A. Bachik - Submit appropriate flight rule changes to reflect FTP decision to use circ pumps for FCS checkout for a previous APU failure.

7. Burn and Recovery Prebank Procedure Problems (walk-on) - DM3/B. R. Hilty

Mr. Hilty briefed the FTP on concerns associated with using existing "Hp" cues for direct insertion OMS-2 only AOA's. Because these burns are primarily radial, the pre-burn rip is often very close to the post-burn (targeted) rip. Consequently, the rip cues are invalid. Mr. Hilty recommended using current burn delta V remaining as the downmode cues instead of rip. The FTP concurred and asked DM to process appropriate FDF changes (not applicable

Ronald D. Dittimore

2 Enclosures