

September 9, 1983

DA8/Chief, Ascent/Entry Flight Techniques

Ascent/Entry Flight Techniques Panel #5 Minutes

The fifth Ascent/Entry Flight Techniques Panel was held on July 27, 1983. The meeting originated at JSC with RIC, NASA Headquarters, Draper, and DFRC tied in via teleconference. The results are summarized below.

## Summary

- a. There will be a manual MCC procedure to compensate the ARD for adaptive guidance throttling on STS-8 (only).
- b. The STS-8 ARCS EI redline (1500 lbs), no maneuver line, and no yaw jet lines were defined.
- c. Normally ST IMU alignments are performed 2 hours 40 minutes prior to T1G. In the event of a one revolution deorbit waveoff, a subsequent 1MU to 1MU alignment will be performed to reset RM detection thresholds. If the one revolution delay would yield a platform misalignment  $> .5$  deg a subsequent ST IMU alignment will be performed.
- e. The STS-8 EOM and AOA runway priorities are EAFB 22 and EAFB 17. NOR 17 is backup in both cases.
- f. The STS-9 EOM runway priorities are EAFB 17, 15, 23, 22. AOA priorities are NOR 17, 23, 25, 05.
- g. An acceptable envelope of postlanding ET umbilical door position, based on door loads during towing and GSE jack clearance, was defined. For acceptable CW landings, the doors will be opened to  $110 \pm 30$  deg.
- h. The STS-7 brake anomaly was attributed to retaining washers which were cracked either in manufacturing or brake assembly. The STS-8 washers have been replaced and found not to be cracked by a post brake assembly inspection.
- i. The STS-8 braking procedures were reviewed and baselined to be the same as the STS-7 procedures.
- j. Accepted a new flight rule which no-go's blackout PTI's if the crossrange is within 105 nmi of the nominal crossrange capability. Hence blackout PTI's would be no-go for 667 nmi and 741 nmi crossranges on STS-8 and 9.
- k. Adopted a new flight rule which facilitates reinitiating PTI's subsequent to exit of blackout. Post blackout PTI's will be attempted if the azimuth error is less than 17.5 deg and the drag reference profile has not dropped more than 1.5 fps<sup>2</sup> from the nominal design profile.
- l. STS-8 EOM and abort c.g.'s are within flight rule c.g. boundaries. TPS simplified model results indicate either primary or alternate elevon schedules are acceptable. Either the heavy or light bending filters are acceptable for EOM with and without payloads. The net result is that auto bending filter/elevon schedule moding can occur for aborts and EOM.

m. To prevent potential HW damage due to rapid cabin decompression during postlanding, RIC recommended that preventing via cabin vent valves prior to side hatch venting be performed at all sites. The recommendation was not accepted.

n. Any EOM/AOA site will be no-go if a thunderstorm is or is predicted to be within 30 nmi of that site.

o. For information, ALE Flight Techniques was briefed on proposed Aeroheating/Thermal operational envelopes by RIC

p. RIC identified an elevon leading edge tile slumping concern with the STS-9, 2 deg up elevon schedule. E&D has submitted a new schedule for approval as a software change.

#### 1. Adaptive Throttle Sensitivities - FM4/M. Henderson

Mr. Henderson briefed us on how adaptive guidance and throttling is implemented, what it's advantages are, and what the mode boundary affects would be for SSME stuck throttle/engine out cases.

Adaptive guidance and throttling provides interactive first stage throttle loads(s) and pitch attitude adjustments to compensate for off-nominal SRB performance. This allows an increase in the allowable dynamic pressure for nominal shaping and decreases the FPR held back for off-nominal SRB performance. For example, the STS-8 cycle 1 performance was improved by 686 lbs (226 lbs for trajectory shaping and 460 lbs reduced FPR). Also the trajectory profiles can be more closely standardized which reduces dispersions and allows standardization of I-loads.

Adjustments to the first stage throttling and guidance are made as follows: Onboard guidance determines a time at which a specific velocity is achieved and compares that to a planned time. This works because prior to load relief (MET -25 sec) SRB dispersions are the only significant contributors to the velocity/time history. The time difference between planned and actual is used to determine sets of I-loads (for hot and cold SRB cases) that are used to determine the SSME load relief throttle profile and the commanded pitch angle profile. The specific formulation is included in enclosure 1.

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The time is on the downlist, but for STS-8, the Abort Region Determinator will need to be manually updated to account for SRB dispersions and the resulting SSME throttle profile. For STS-9 and subsequent the ARD will automatically compensate using T/M.

Enclosure 2 is representative of stuck throttle cases and abort regions required with a subsequent engine out. The throttle level of one engine was frozen (i.e., did not return after thrust bucket throttle-up) to generate this data.

#### 2. RCS Redlines (Standard) and STS-8 Cue Card - DF6/D. W. Whittle

Mr. Whittle reviewed RCS redlines and the RCS quantity checks on the Entry Maneuver cue cards.

As reported previously, there are two basic sets of entry redlines. The first set is for c.g.'s aft of X-cg = 1088 while the second set is for c.g.'s forward of X-cg = 1088. Enclosure 3 provides both sets. The

difference between the two sets EI (no maneuver) and no-yaw-jet redlines is approximately 170 lbs. Because STS-8 c.g.'s are all aft of X-cg = 1088, the crew will only carry onboard one RCS Critical Entry cue card with the enclosure 3 redlines therein. Likewise, the other set will be onboard for STS-9.

The STS-8 EI redline is 1500 lbs. This number reflects the "no maneuver" EI requirement of 1380 lbs plus 120 lbs PTI #1, 2 usage. The 120 lbs was added to the 1380 lbs so that PTI #1, 2 would not be lost due to the possibility of the steep slope on the actual usage curve dipping below the no maneuver line at the QBAR=1 RCS quantity check. If that occurred, PTI's would be no-go until the D=1 RCS quantity check. This is depicted in enclosure 3.

There are no changes to the FCS procedures on the RCS Critical Entry cue cards. The only changes will be the go/no-go checks for PTI's and the shape of the actual usage curve.

### 3. LMU Management for Waveoffs - DF6/D. W. Whittle

Mr. Whittle discussed LMU management for deorbit waveoffs. The question is how to manage the IMU's (i.e., what type of alignment and when) such that their misalignments do not seriously degrade attitude and velocity data thereby impacting flight performance and such that RM's ability to detect and isolate attitude faults at the two level is not seriously degraded. At STS-3 EFTP #4, FM5/J. Harpold identified a misalignment of less than .25 deg at EI as highly desirable and a misalignment of .5 deg as a flight safety limit. IMU BITE covers approximately 89 percent of potential HW failures with RM covering the remaining 10 percent. RM's two level attitude fault detection (AFD) degrades with time. Mr. Whittle provided the enclosure 4 data to describe the RM degradation.

If there is a one revolution delay, the minimal thing that will be done is an IMU to IMU alignment to reduce the RM degradation. The MCC monitors drift rates and compares them to select the IMU to which the others are aligned to. If it is predicted that the one revolution delay will result in a platform misalignment of .5 DEG at EI, a ST alignment will be performed to get the alignment down to less than .25 deg. The mission rules were so amended.

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### 4. Entry Site Selection Priorities - DH3/W. M. Bolt Š

Mr. Bolt briefed the STS-8/9 EOM and AOA runway priorities. They are as follows:

FLIGHT	EOM	SECONDARY EOM	AOA	SECONDARY AOA
STS-8	EAFB 22 EAFB 17	NOR 17	EAFB 22 EAFB17	NOR 17
STS-9	EAFB 17 EAFB 15 EAFB 22 EAFB 22	NOR 17 NOR 23 NOR 35 NOR 05	NOR 17 NOR 23 NOR 35 NOR 05	

There will be a 1-day delay prior to EOM to NOR in hopes of better EAFB weather. EAFB 22 was made prime due to night visibility concerns with dust at EAFB 17 induced by the Orbiter during rollout. KC 135 night landing visibility at EAFB (lakebed and concrete) and NOR indicated acceptable visibility at all sites.

#### 4a. Postlanding ET Doors - Tolerance - Rockwell

The ET doors were opened on STS-1 to the vertical position due to a concern for potential H2 build-up in the ET umbilical door cavity. The vertical position was selected to minimize loads on the door mechanisms. STS-1 flight experience indicated that inflight MPS vacuum inerting was effective and that the doors need not be opened in the future. The one exception is GRTLS where vacuum inerting is not performed. Hence, on flights STS-2 through STS-6 the ET doors were not opened by the crew. Starting with STS-7, KSC likes to have the crew open the ET doors during postlanding to facilitate ground handling at KSC, EAFB, NOR, etc. With the crew opening the doors, GSE electrical power need not be applied to open the doors. On STS-7, differences in door motor performance resulted in doors not exactly to the vertical position. RIC was asked to identify tolerances on door opening.

Allowable tolerances on ET door position are defined by acceptable wind loads on the door mechanisms and by clearance of the GSE jacks positioned at the jack points. RIC/A. J. Richardson identified acceptable door positions as a function of crosswind component magnitude for the static and towed Orbiter. Subsequent to the meeting, RIC/G. Yaeger identified GSE clearance requirements. Enclosure 5 provides the resulting envelope.

#### 4b. Postlanding ET Doors - Opening Procedure - DF4/B. L. Jenkins

Mr. Jenkins reviewed door opening tests and revised postlanding procedures. The right ET door took 12.1 seconds to achieve the vertical position while the left took 11.9 seconds. Because the crew and MCC have no indication of door position, the crew must time how long they have the door motors running. Mr. Jenkins recommended 13 seconds for dual motor drive time and 26 seconds for single motor (MDM or bus failure case) drive time. Procedures were provided which would result in door positions inside the acceptable envelope previously discussed.

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Subsequent to the meeting, using the door position envelope, motor drive times were changed to 15 and 30 seconds and a flight rule written identifying acceptable door position as  $100 + 300$ .

#### 6. Braking Results (STS-7) and Procedure Recommendation for STS-8 - ET5/J. E. McCullough

Mr. McCullough discussed the STS-7 brake anomaly and impacts on STS-8. The crew did not note any degraded braking but brake noises during towing indicated potential damage. Postflight inspection indicated no heat damage due to high energy braking. The right inboard (RIB) had structural failure to two rotors while the ROB had two carbon pads loose with retainer washers missing. Cracked retainer washers were found in all brake assemblies. It was concluded that STS-7 damage was caused by loss of retainer washers. Enclosure 6 illustrates how retainer washers hold the carbon pads on the rotor beryllium heat sink prior to brake application. The STS-8 brakes were inspected and also found to have cracked retainer washers. The STS-7, 8 retainer washers were provided by a new vendor who used a different grade of columbium than the old vendor, were also found. The conclusion was that retainer washers were cracked during manufacturing and assembly. Damaged retainer washers have been replaced on the STS-8 brakes and they were inspected after assembly. Mr. McCullough felt no changes to the existing braking procedures were needed.

CB/B. D. O'Connor reviewed the STS-8 braking procedures provided in Enclosure 7. There are no changes from STS-7 procedures.

7. DTO Crossrange/Energy Criteria (STS-8/9) - FM5/J. C. Harpold

STS-7 had a large crossrange for its landing. Because of energy concerns, PTI's prior to exit of blackout were canceled. PTI's subsequent to exit of blackout were performed. STS-7 premission planning has only utilized a maximum crossrange number for PTI cancellation. During the flight, MPAD devised guidelines to facilitate postblackout PTI's. Mr. Harpold discussed proposed performance related flight rules dealing with PTI inhibits. Rules as adopted by A/E Flight Techniques are:

a. Aero test maneuvers during blackout will not be attempted if the crossrange at entry interface is within 105 nmi of the nominal crossrange capability. (This is a pre-deorbit MCC call.)

b. Aero test maneuvers will be attempted postblackout if the azimuth error is less than 17.50 and the drag reference profile has not dropped more than 1.5 fps<sup>2</sup> from the nominal design profile. (This is a postblackout call that requires both T/M and tracking).

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The STS-8/9 crossranges and DTO inhibits are as follows:

	STS-8	STS-9 (CY1)	
PTI's)	Nominal Capability	772 nm	846 Š (with
	3 sigma Guaranteed (without PTI's)	710	784
	DTO Inhibit	667	741

8. STS-8 CG, Aero Surface Temps, and Bending Filter Recommendation - RIC/HI

RIC/R. L. Haben reviewed the TPS simplified model results for the STS-8 c.g.'s, elevon schedules, etc. TAL temperatures are less than or equivalent to STS-7 temperatures. EOM and abort temperatures (enclosure 9) were reviewed by RIC/E. Schlessinger, M. Wilson, W. Cases, and J. Haney and found to be acceptable for all cases with both elevon schedules.

HI/R. Hamilton reported on bending filter requirements. Either the heavy or light weight filters are acceptable for EOM with or without a non-deployed PL. When combined with the aforementioned thermal flexibility in elevon schedule, the crew need not take any action other than to allow automatic elevon schedule/ body bending filter moding for aborts and EOM.

9. Cabin Pressurization Equalization Recommendations - RIC

Pressure equalization can be done either via cabin vent valves or with the side hatch in the pause position. Current Entry Checklist (C/L) procedures call for the CDR to equalize cabin and ambient pressures via the Panel L2 cabin vent isolation and cabin vent switches only at NOR if the cabin pressure is > 15.1 psi. If those conditions were not met, equalization would be via the side hatch in the pause position. RIC/A. J. Richardson and I. J. Alongi discussed the effects of cabin rapid

decompression induced by early side hatch opening and recommended changes to the Entry C/L.

Cabin rapid decompression could occur if a ground support technician opens the side hatch prior to pressure equalization, if the crewman did not stop at the vent position for a sufficient amount of time while he was opening the hatch, and if the side hatch no-back device failed. The maximum 4P's for primary and contingency landing sites (CLS) are provided in enclosure 10. They range from +1.1 psid KSC to +3.2 psid (NOR). Enclosure 11 provides a summary of potential HW damage due to rapid decompression. The minimum allowable 4P of .26 psid is a Safety concern with potential injury to a ground support technician if the hatch was to swing open rapidly. Hatch loads have been provided in enclosure 10. Venting times for the side hatch and for the cabin vent valves presented in enclosure 12. Worst case cabin vent valve venting requires approximately 4 minutes while side hatch venting for like conditions takes approximately 22 seconds.

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Mr. Richardson and Mr. Along recommended "pre-venting" the cabin through the cabin vent valves at all landing sites when the cabin/ambient dP exceeds + .25 psid. The crew would utilize the panel 01 dP/dT display venting when the display indicated 0 dP. This should be followed by standard hatch opening procedures which include pausing for side hatch venting. This "second" venting would account for dP/dT display inaccuracies, and any build-up in + dP (i.e., if 14.7 psi regulators used or thermal build-up) that has occurred since termination of the cabin vent valve venting with vent closure. The optimum time for cabin vent valve venting completion would be just prior to hatch opening.

None of these recommendations were accepted, and the issue was referred to the Program Systems Operations Office for direction, if they so choose.

#### 10. Proposed Weather Rule Changes-ZS8/J R. Nicholson

Mr. Nicholson reviewed a number of potential changes to flight rules dealing with weather criteria. The first was whether or not to change the EOM, daily go/no-go, and RTLS cloud cover/ceiling limit from 50 percent cloud cover to a 15 KFT ceiling. This item was not resolved and was scheduled for A/E Flight Techniques #6. The second was whether or not a temperature and dewpoint constraint should be devised as a "fog limit." The A/E Flight Techniques concluded that present visibility criterion, which is subject to STA pilot evaluation, is superior to any temperature/dewpoint criterion. Prior to STS-7 a thunderstorm constraint was devised such that KSC will be no-go for landing if thunderstorm/ rain is actually within 30 nmi of the SLF or is projected to be within 30 nmi of the SLF at landing time. This criteria was adopted for all other landing sites for EOM and AOA. This criteria is not applied for RTLS and TAL where LCC reflects a 2 nmi above and/or 5 nmi horizontal clearance from a cloud with a radar echo.

#### 11. Aeroheating/Thermal Analyses Operational Envelope (Entry) - RIC/J. Haney

On a "for information" basis, A/E Flight Techniques was briefed by Mr. Haney on operational envelopes proposed for the SODB. These envelopes only reflect RIC Aeroheating and Thermal Analyses proposed envelopes and do not reflect a unified RIC position. Effort should be directed towards verifying the validity of the envelopes below M 12. Indeed, if the lower

Mach elevon and body flap positions are valid, there is a potential aeroheating issue with scheduled positions on STS-8 and 9. The envelopes are provided for reference only.

These envelopes are believed to be too conservative They were referred to E&D. No techniques action will be taken.

#### 12. STS-9 Thermal Issue - Rockwell

For information, Mr. Haney briefed the A/E Flight Techniques on potential thermal issues with the STS-9 elevon schedule. The STS-9 elevon schedule is -2 deg (up). STS-7 had a -1 deg (up) elevon schedule and evidenced tile slumping on the elevon leading edge. Mr. Haney felt that with the elevons further up than STS-7 and with higher heating due to higher inclination and weight, the potential for turnaround impact was present. A different STS-9 elevon schedule of + 5 deg (down)

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had been proposed by the aerodynamic data community to expand knowledge in this regime. Mr. Haney felt that the resulting up body flap would evidence the same problem as the up elevon. The new STS-9 elevon schedule is to be submitted to the software board.

#### 13. STS-9 Toggling - FM5/J. Hansen

This item was deferred to A/E Flight Techniques #6.

Gary E. Coen