

DA8/Chairman, Ascent/Entry Flight Techniques

Ascent/Entry Flight Techniques Panel Meeting #9 Minutes

The ninth Ascent/Entry Flight Techniques Panel was held on Friday, March 9, 1984, at JSC. Rockwell, Headquarters, and DFRC participated via teleconference.

Summary

a. E&D is dropping its braking procedure requirements because of the overall satisfactory performance of the brakes through STS 41-B. However, since it is desirable to avoid zero applied brake pressure, the flight crews will maintain relatively high deceleration to account for possible differential braking due to crosswinds. An erroneous braking pressure modeling in the simulators is being corrected to improve training.

b. The discrepancy between the measured and aero-calculated Xcg during STS 41-B of about 3 inches was found to be due to a problem in the modeling of FCS responses.

c. STS 41-B descent navigation performance overall was good, but there was a ~25K foot downrange error between the onboard and ground solutions post-blackout. Atmospheric density gradients causing drag estimation errors in the covariance matrix are believed to be responsible. The error disappeared after TACAN was acquired and updated the onboard state.

d. Some new techniques to improve aim point selection/waveoff criteria at KSC were reviewed. For STS 41-C only it was decided to use the current technique except that if the predicted touchdown is <1000 feet even with the high wind aim point, either the other end of the runway would be selected, or the landing waved off. Some discrepancies between STA predicted, MPAD predicted and actual touchdowns need to be accounted for. Extra balloon releases closer to landing were planned for STS 41-C.

e. MPAD analysis shows that there would be no Orbiter thermal problems with prebanks from 0 to 90 degrees for a STS 41-C deorbit from 285 nmi.

f. The STS 41-C runway priorities and STS 41-0 landing opportunities were reviewed.

g. The current status of the Autoland DTO for STS 41-F was reviewed.

-1-

h. The effect of and procedures to perform a post-MECO LO2 dump inhibit were discussed. It was decided not to include this in the FDF, but handle as a real-time call, because of the low probability of being required, and the procedure is not supported by the software (based on a SAIL run).

1. Brake Results STS-9/STS 41-B and Procedure Changes - EK/R. H. Bradley
The braking summaries for STS-9 and STS 41-B were presented (enclosure 1). Both flights suffered some damage on the right outboard brake only, with number 4 rotor being damaged on both, and number 3 rotor suffering slight damage on STS 41-B. STS-7 and STS-8 also suffered some brake damage, but most of the damage on STS-7 occurred during tow. The brakes were removed before towing on STS 41-B to inspect their condition, but the brakes will not

be pulled before tow on STS 41-C. The deceleration rate on STS 41-B averaged about 5-6 fps² and was lower than intended. The pressure oscillations seen during braking are as yet unexplained.

Mr. Bradley stated that it is now their recommendation based on braking results so far, that braking procedure techniques as specified by E&D be dropped, and the actual procedures be left up to the crew. Although they believe there is no likely brake failure that can cause serious results, it is desirable to maintain some pressure on each brake during rollout to reduce the likelihood of rotor chips breaking loose and jamming between the pads. Zero brake pressure maximizes the distance between the pads. Although it is desirable to have pressure applied to each brake, every flight to date has experienced zero pressure at some point. In the charts (enclosure 1) zero pedal pressure equates to about 200 pounds brake pressure. A large crosswind (15 knots) during rollout could require about 10 fps² deceleration to prevent backing off of one side completely and maintain a straight pull. One brake on full and the other off will produce about 8 fps².

Although the E&D requirements for braking procedures are being dropped, it is still desirable to maintain high enough deceleration to prevent zero brake applied pressure even during crosswind, so it is the intention of the flight crews to stay on the high end of the braking cue card. However, the rollout margin and energy margin limits for rules purposes will use an average of 7.5 fps².

It was noted that for nearly every flight, the actual braking deceleration was lower than specified. One reason cited was the problem of adapting back from a weightless environment, but there was considerable surprise at the meeting when it was revealed that the brake pedal pressures in the current simulators are about half that in the actual vehicle. The resultant misleading training in braking effectiveness is probably the main reason for the lower decelerations. This problem is being fixed in the simulators.

-2-

2. STS 41-B CG Analysis MD2/E. P. Hischke

The CG assessment for STS 41-B based on weight and balance measurements and calculations is shown in enclosure 2. The difference between the real-time (deorbit -6 hours) prediction and postflight calculation of the Mach 3 Xcg was 0.9 inches (1088.5 vice 1087.6 inches). As shown in the enclosure, 0.8 inches of this difference has been explained. Most of the differences due to some uncertainty in predicting the OMS usage during the deorbit burn. However, as reported in the last meeting, there is a large discrepancy (3 inches) between the weights/balance calculated CG and the CG calculated from the aero (control surfaces trim, etc.). This large discrepancy was still unexplained, but Mr. Hischke stated that they feel confident in the validity of the weights-calculated CG. Postlanding weighing has shown there was little or no CG error. Subsequent to this meeting, the problem was found to be in the modeling of FCS responses.

3. STS 41-B Navigation Performance - FM8/G. Goodrum

The "quick-look" preliminary assessment of the STS 41-B navigation performance was presented (enclosure 3). Overall the navigation performance was good, with one major anomaly occurring. This was the large downrange (V position) difference (~25K feet) between the ground and onboard solutions post-blackout. The ground filter converged at about 140K feet, and the onboard filter converged when the TACAN was acquired and fed into the navigation state at about 130K feet. The BFS converged when the state vector was transferred at about 110K feet. The downrange error of 25K feet was approxi-

mately 2.5 sigma. The previous worst downrange error was 10K feet on STS-7. This navigation error was not due to IMU misalignment (all three produced similar results), but is believed to be caused by atmospheric density gradients that allow drag estimate errors to adversely affect the covariance matrix. There are no fixes in sight for this problem.

After the onboard navigation converged with TACAN acquisition, only small state errors occurred for the remainder of the descent. All the measurement data were processed as expected. The large (40 degree) glitches shown in the enclosed chart for TACAN LRU 1 bearing caused the RM to fail LRU 1 bearing

data (a 2 degree difference between ground and onboard was predicted pre-flight). The MSBLS appears to be working normally, but the MSBLS azimuth showed the effects of the cross polarization of the antennas. The "new" antennas were installed at EDW 17 and 22, but had not yet been corrected at KSC.

4. KSC Aim Point Preference Based on Weather Statistics - FM5/J. V. West

Mr. West presented the results of the landing targeting for STS 41-B and some possible options for targeting the aim point at KSC. We have had good matches (within noise level) between predicted and actual touchdown points

-3-

for all flights except for STS-1 and 2 (which had bad aero). The results from STS 41-B are shown in enclosure 4. There is some concern about using the nominal aim point at KSC where dispersions (especially during winter) can cause the touchdown to be close to the runway threshold. As shown in enclosure 4, using the nominal aim point, a typical KSC touchdown during winter with a 10 knot headwind could have a touchdown point of between 900 and 1500 feet (versus the targeted 3000 feet point). Based on weather statistics, a high wind aim point would be required at least 50 percent of the time. The current baseline technique for landing targeting calls for a 285 KEAS on the outer glideslope, retracting the speedbrake (SB) at 2500 feet altitude. If the touchdown point (normalized to 195 KEAS) is less than 1000 feet, then the high wind aim point is selected.

The first histogram in the enclosure shows the scatter of touchdown points for 200 cases (147 used high wind aim point) using randomized wind and weight, and a steep glideslope. Several cases landed less than 500 feet, and three did not reach the runway. Six possible options to increase the touchdown point margins are shown in the enclosure. Of these, the last three are not desirable, and the third option (new auto speedbrake software) will not take effect until STS 51-D. Mr. West suggested four possible new techniques to deal with the aim point (enclosure 4). Techniques A and B retract the SB at 4000 feet, while techniques C and D use a higher approach speed (290 KEAS on outer glideslope) and retract SB nominally at 3000 feet, and at 4000 feet for the high wind aim point. For all of these techniques, if even after selecting the high wind aim point and retracting the SB earlier predicted touchdown point is still less than 1000 feet, we could possibly try the other end of the runway if the tailwind is not too high (-10 knots).⁶ The end result is that we need an energy limit for waveoff at KSC, and this will require further discussion.

The summary of results for techniques A-D based on 200 cases (as used with the basic technique) is shown in the table in the enclosure. The percentage of wave-offs (not considering swapping to other end of the runway) dropped from about 21 percent for the current basic techniques, to about 1.5 percent for techniques C and D. It was recommended by Mr. West that techniques A or

B be used through flight STS 41-E, and that technique C or D (which requires changing I-loads for Vref to 290 knots and SB retract altitude) be used thereafter.

It was decided that for flight STS 41-C only, we will use the current baseline technique, except that if after selecting the high wind aim point the predicted touchdown is still less than 1000 feet, we will NO-GO that end of the runway, evaluate using the other end and waveoff if that is out of limits. The technique to be used for later flights still needs to be decided.

-4-

5. 45 Degree Prebank Thermal Effects on STS 41-C - FM5/J. Hansen

This presentation was the result of an action assigned at the last flight techniques meeting. There was some concern about possible thermal effects of deorbiting with a 45 degree prebank from a altitude of 285 nmi. Although this prebank is no problem thermally at the previous lower altitudes, it was considered prudent to see if this result is also true at the higher altitude. MPAD performed the analysis for prebanks of 0 to 90 degrees. The analysis shows that there is no problem thermally for the Orbiter with prebanks up to 90 degrees. However, it turns out that a 45 degree prebank only buys us about 7 fps delta V at 285 nmi, while the same prebank from 150 nmi has a delta V savings of about 16 fps. The lower savings from the higher altitude is due to sensitivity to entry window dispersions.

6. CG Thermal Constraints Due Thermal Analysis - FM5/J. C. Harpold

MPAD has determined the CG ranges needed to support the elevon schedules for flights STS 41-C through STS 41-G, and these are shown in enclosure 5. These CG boundaries have been provided to Rockwell for thermal certification. The results of the Rockwell analysis will be presented at a later date. They will be added to the individual rules annexes.

7. STS 41-C LDEF Return Case Landing Site Recommendation - DH3/G. T. Oliver

The LDEF return case (weight =220K pounds) has an upper density altitude limit of about 3,300 feet to maintain a 3,000 foot runway margin (enclosure 6). Based on this and the crosswind constraints shown in the enclosure, it was recommended that for the LDEF return case, the landing site be KSC with 8 fps² deceleration. The absolute crosswind limit for this configuration is 12 knots.

7a. History of STS 41-C Touchdown Points (Walk-on) DH3/G. T. Oliver

One of the concerns about KSC landings is the prediction of the touchdown point. The three major means of predicting the touchdown point are a MPAD offline analysis, the STA, and the SMS. A summary of the predicted and actual touchdown points for STS 41-B is shown in enclosure 7. The MPAD offline analysis is based on balloon data, but did not include the actual density profile. Touchdown points for both the nominal and high wind aim points were predicted. There is a large discrepancy (of 1065 feet) between the MPAD analysis and the SMS predicted touchdown - 6-1/2 hour touchdown point. This discrepancy was caused by the SMS using the nominal aim point. Another large discrepancy in the predictions was between the STA and the MPAD analysis. The actual touchdown point was much closer to the MPAD prediction than the STA prediction, and it appears that although the STA provides good weather conditions/visibility information, the touchdown prediction and aim

-5-

point chosen should be based on the MPAD analysis. The validity of the STA

simulation for landing prediction needs to be verified. To accomplish same, an extra set of balloon releases closely timed to STA landings will be planned for STS 41-C.

Action: 03/09-001 - FM5/J. C. Harpold - After STS 41-C provide correlation/conclusions from balloon/STA touchdown point study.

8. Payloads Impacted by Early Postlanding Power Downs through STS 51-A - DH6/M. K. Fawcett

The only payloads identified that have postlanding power requirements are CFES (STS 41-D and STS 51-A) and MLR (not currently manifested). CFES requires power to operate the active cooling (via payload heat exchanger) until the product example is removed, and the MCR requires power to operate the sample stirrers. However, both of these payloads comply with the current flight rules for postlanding power down. There was a question concerning the effect on the payloads of a contingency landing where no convoy support is available, and some clarification is needed on the support provided to the payloads by the minimum support convoy.

9. CG's for STS 41-D - Rockwell

Deferred

10. Elevon Schedule and Bending Filter Requirements for STS 41-D - Rockwell

Deferred

11. Thermal Analysis Results for STS 41-D - Rockwell

The preliminary thermal analysis results for STS 41-D nominal EOM indicate no major problems, although there are a few possible points of concern. The OV103 roughness factor needs to be revised and included in the analysis. The detailed results of the analysis will be presented at the next meeting.

12. STS 41-D Landing Opportunities - FM5/L. Gonzales

The current STS 41-D landing opportunities and PTI capability are shown in enclosure 8. The nominal EOM landing is on flight day 7, rev 112 at KSC. There is only one KSC, EDW, and NOR daylight opportunity per day at EOM, EOM

-6-

+1 and 2 days. The possibility of accepting a night landing as a backup opportunity should be considered in the crew training plan.

13. Autoland DTO - DA6/R. A. Thorson

Mr. Thorson presented the current status of the autoland DTO. The major timeline events and schedule in preparation of performing the DTO on STS 41-F is shown in enclosure 9. At the time of this presentation, the STA verification runs were underway. The STA autoland work done prior to STS-5 was postponed because of a software problem (erroneous calculation of VI) which caused inconsistent results. This problem was fixed, and STA verification testing started in October 1983. However, a hardware problem caused oscillations during approach, and testing was stopped to fix the problem. Testing was resumed in November, and the data looked generally good, but the winds were not as required. The runs in December showed large dispersions, but these were greatly reduced (to 7-8 knot dispersions) in the February runs. However, the February STA runs experienced a relatively high descent rate (H DOT) at touchdown of about 3.5 fps. The March runs were designed to reduce the H DOT.

The STS-6 aero data (FAD) showed a sign change in the pitching moment due to ground effect. The resultant change in the pitching movement coefficient was incorporated in all the simulators except for the SMS (incorporation is due with the 1402 loads in mid-April) and the STA software prior to March. This is believed to be the reason for the high H DOT in the February runs (when negative pitching is induced, the elevons rise causing lift to decrease, thus increasing H DOT). It also turns out that only the heavy weight IC's have been delivered to the SMS so far, and the light weight IC's are needed for STS 41-F. The incorrect pitching movement characteristics in ground effect with off-nominal environments and wrong weight IC's have caused concern about the validity of crew training in the SMS, and even when these problems are corrected, not much training time is left before flight. It is very important to expedite the SMS modifications to provide adequate exposure and training for the crew, and also to evaluate the effect of variations in the simulators.

Another problem encountered was a case where two electrical failures could put the WOW/WONG in the TAEM region, which would also be uncontrollable in CSS. A CR fix for this problem is in work and should be incorporated before flight. As a final note, non-STA simulations have shown nominal landings occurring about 800 feet short of nominal touchdown, with H DOT 1.9 fps and SEAS 196 knots. All simulators use a 300 feet landing gear deployment altitude.

14. STS 41-C Runway Priorities (Walk-on) - DH3/G. T. Oliver

The runway priorities for STS 41-C are shown in enclosure 10.

-7-

15. Post-MECO LO2 Dump Inhibit (Walk-on)

a. Weight and CG Effects - Rockwell/R. Young

Rockwell calculated the CG and weight effects of inhibiting a MPS LO2 dump post-MECO (enclosure 11). For an underspeed (U/S) AOA, the minimum amount of LO2 left at E1 is 1550 pounds, while for a system AOA the amount left is 2250 pounds. For the U/S AOA case, the LO2 remaining causes a delta X cg of 1.5 inches, which corresponds to 1023 pounds of propellant (OMS) that is available without violating the CG constraints.

b. Procedures - DG6/J. M. Howard

The FDF procedures for inhibiting the LO2 dump were presented, but it was decided that this will be handled as a real-time call because of the low probability of this nose heavy case occurring. The procedure was run in SAIL and the software did not support the inhibit. Therefore the procedure was dropped for STS 41-C.

T. Cleon Lacefield