

July 28, 1983

DA8/Chief, Ascent/Entry Flight Techniques

Ascent/Entry Flight Techniques Panel #4 Minutes

The fourth Ascent/Entry Flight Techniques Panel was held on June 3, 1983. The meeting originated at JSC with Rockwell, NASA Headquarters, Draper Laboratory, and DFRC tied in via teleconference. The results are summarized below:

Summary

a. KSC will be no-go for landing if thunderstorm/rain area is predicted to be or is actually within 30 nmi of the SLF at landing time. Note that a straight in approach to KSC is technically too close to limits, but was judged acceptable.

b. Braking profile recommendations were reviewed. The nominal profile is to initiate braking at 140 to 120 KGS and decelerate at 6-10 fps² to 20 KGS. At 20 KGS, braking is reduced to 6 fps². The crew intends to use only differential braking to control a crosswind. For a non-crosswind nominal landing, it appears brake refurbishment will not be an issue. For crosswind landings, the procedure could lead to brake refurbishment, but not failure during rollout.

c. RCS entry redlines were reviewed. STS-7 EI redline is 1380 lbs. The TIG redline is an additional 160 lbs to account for usage between EI and TIG. There is another 90 lbs to assure PTI's which may be available if higher priority DTO's do not require it.

d. Accepted a Rockwell recommendation for an I-load change (STS-8/9 effectivity) which would delay the TAL roll maneuver. The result is to provide a better balanced ET tank thermal environment which would increase separation distance at tank rupture. The 2 SSME out TAL window could open approximately 15 seconds earlier.

e. Simplified TPS model results indicate a potential safety-of-flight issue for the chine during a TAL. Same problem was seen for STS-6. Rockwell/thermal and JSC thermal are preparing a recommendation for the STS-7 FRR.

1. Predeorbit KSC Thunderstorm Criteria - ZS8/J. Nicholson

Mr. Nicholson presented a brief summary of the sources of thunderstorms in the KSC area, and a proposed set of criteria for avoiding them. There are two main weather patterns that could result in thunderstorms in the KSC area: a frontal system moving through (usually from the NW), and a disturbance in the easterly flow. The first causes the almost daily thunderstorms, but is considered unlikely for STS-7 because of the early morning landing time. The disturbance in the easterly flow can cause showers and thunderstorms in the morning and is more likely to cause a

problem for STS-7. The actual constraint for the Orbiter to avoid thunderstorms is to get no closer than 5 nmi laterally and 2 nmi above

the boundary of the storm. Added to a 15 nmi HAC, this means a limit of 20 nmi from the runway. However, an additional estimation pad was added to come up with the proposed criteria of no-go for the landing if there is a thunderstorm/rain area within 30 nmi of the KSC runway or is projected to be within 30 nmi of the runway at landing time. The decision time to no-go the landing site is landing -2 1/2 hours, although contingency action can be taken after entry if required as discussed at earlier meetings. The detailed proposed criteria are shown in enclosure 1. These criteria are based on experience, but have not been rigorously tested. Actually, cloud cover early in the morning is likely to be more of a problem than thunderstorms for STS-7. The probability of not passing the cloud cover criteria is about 50%, while the estimated probability of having a thunderstorm is only about 3-4%. To clear the highest of storms by >2 mi, it was decided that the Orbiter should have an altitude of at least 60,000 ft when it passes over a thunderstorm. Since the meeting, Rockwell has determined that a nominal (i.e., non-dispersed) straight-in approach to KSC 15 will cross the 30 nmi mark at about 53,000 ft. If straight-in is required and a 'tall one' is seen, there we will be no-go.

2. Braking Recommendations - ETS/C. Campbell

The concern here was to come up with a standard braking procedure that crews can train to which will not exceed brake reuse energy limits for crosswind control and yet allows ample runway margins on concrete runways such as KSC. The braking limits and performance of the brakes on recent flights is shown in enclosure 2. Higher brake-on velocity and higher deceleration contribute to higher brake energy (see table in enclosure 2). However, prolonged rollouts on the lakebed are harder on the tires because of rolling friction heat build up with long rollouts, while the brakes are thermally isolated from the tires. The baselined standard braking procedure is to apply the brakes at 140-120 kts at 6-10 ft/sec² deceleration until near the end of rollout (20 kts). From touchdown until the start of braking, steering will be done using the rudder. Rudder steering is not as effective with the speedbrakes out, but should be effective to 140 kts. After brake application, steering will be accomplished using differential braking, but can be supplemented with nosewheel steering if necessary. Normally nosewheel steering will not be used. With crosswinds, vehicle handling and control capability are more of an issue than brake performance. E&D analysis indicates that below about 138 kts, the brakes would remain functional, even if stood on (i.e., full pressure applied to a single brake). The single brake reuse energy limit was limited to 42 million ft-lb on the worst case brake, considering crosswinds. For abort cases we are willing to give up this brake constraint as necessary, and so we will go up to the brake failure limit of 55 million ft-lb if necessary.

For the case where there is a premature brake pulse (as occurred on STS-5), the agreed procedure is to start braking at approximately 140 kts with a constant deceleration of 6-8 ft/sec². The intent here is to minimize coast time and heat soak back into the stators.

The brakes will still be effective with one APU down and can stop the vehicle with the nominal margins. There was much discussion about whether the Orbiter should go to a lakebed runway with one APU down and heavyweight, and if so, what weight should be the cutoff. It was decided subsequent to the meeting to add a mission rule that states that the landing site and runway will be selected to keep individual brake energy levels under 42 million ft-lb and yet stop with a 3000 ft runway margin. This will require a prelanding evaluation based on such factors as vehicle weight, runway length and winds for concrete runways.

3. Braking/Distance Capabilities - FM5/J. Harpold

Deferred. Subsequent to the meeting MPAD developed a data package that will be used for the above brake energy evaluation.

-2-

4. RCS/Entry Redlines - DF6/D. Whittle

The overall objective is to develop a standard RCS redline procedure that will only require changes each mission based on the PTI profile. Eventually it is desired to have a single set of criteria, but we currently have two entry redlines - one for forward c.g. (forward of 1088) and the other for aft cg (aft of 1088). The c.g. value used is the M 3.5 value. The "no way jet" requirement is c.g. sensitive. The STS-7 entry maneuver RCS redlines are shown in enclosure 3. The development ground rules and breakdown of the RCS requirements included in generating the redline values are also shown in enclosure 3. The forward c.g. RCS redline value at El is 1550 lbs, and the aft c.g. El value is 1380 lbs. The actual predicted nominal usage for the pti's is shown in enclosure 3. Although the aft c.g. redline requires 1397 lbs, which means 17 lbs short for PTI's 2 and 3, there is actually a reserve of 160 lbs which is made up of one day waveoff propellant and OMS engine failure protection. This means that on a nominal first day attempt we should get all the entry PTI's, even if we lose an OMS engine. For STS-7, the PTI usage is low at high Mach numbers, and it has been decided to keep the STS-7 budget as is. This trades off the upper PTI's against environmental uncertainties (i.e., off nominal atmosphere), but with the 250 lb. total reserve it should be adequate. In the MPAD planning, to determine loading, the PTI usage is added above the nominal entry line, which includes propellant for 3 sigma reserves. For real-time planning have developed a "no go maneuver line" that protects a "no yaw jet" entry and 3 sigma without PTI's. Considerable discussion ensued as to how to develop the PTI allotment that could be given up to allow higher priority on-orbit DTO's. At a subsequent meeting, we agreed to allow only the propellant allotted to an OMS engine failure be applicable to entry PTI's

5. TAL Roll Maneuver Change - RIC/R. Thiel

The current philosophy of designing abort mode ascent trajectories is to maintain the heads down attitude as long as possible before initiating the heads-up maneuver. This maintains similarity to the nominal ascent attitude as long as possible, and has remained within the ascent aeroheating analysis data base. However, analysis has shown that there is a problem with ET rupture before MECO due to aeroheating. This ET rupture time limited the TAL single-engine press point by 15 seconds. Rockwell has done a point analysis of the ET with the roll maneuver initiated at different times. The analysis showed that by rolling earlier, the heat load on both the LOX and LH2 tanks could be reduced. However, if the roll is done too early, the heat load becomes too large on the other side of the ET and early rupture again results. It was thus decided to try a "mid-roll," which in effect shares the heat load between both sides of the ET (i.e., a "barbeque" mode) and results in much later rupture times. The results of the analysis for a late roll (16,200 fps), early roll (11,600 fps) and a mid-roll (13,000 fps) are shown in enclosure 4. The temperatures at points on the LOX and LH2 tanks are shown, on both sides of the ET (180 deg apart). It can be seen that although a late or early roll gives cooler temperatures than the mid-roll on one side, the point 180 deg around the ET is hotter and has the potential for causing burn-through and ET rupture. The mid-roll point was chosen arbitrarily and the

actual point has not been optimized. The mid-roll maneuver also increases the single-engine TAL exposure (by 15 seconds) and provides additional margins for expected higher WTR heating environments, and lowering the MECO target altitude to reduce entry heating effects.

It was decided to baseline the mid-roll maneuver and try to get it I-loaded for STS-8. The ARD will also have to be changed. The manual roll backup procedure will have to be tested in the SES/SMS since the vehicle attitude is different and not as benign at 13,000 fps as at 16,000 fps.

-3-

6. STS-7 TAL Heating Concerns - Rockwell A Rockwell cursory analysis of five lower surface control point temperatures (enclosure 5) has shown a potential problem at control point 5 on the chine for STS-7 TAL. The temperatures shown in the table are not correct but are consistent between flights and are good for show in temperature deltas from flight to flight. The temperature shown for the chine is the pea during pullout, and is only a spike. The average temperature is lower than this, and even lower than EOM. The concern is of a possible burn-through of the structure with unknown results. Rockwell is conducting a risk assessment. We had the same problem on STS-6, but lack of funding prevented a full analysis of it and no action was taken to alleviate the problem for that flight. However, for STS-7, all the tile gaps are being filled and this could alleviate the problem. Rockwell is working towards an explanation or waiver before the FRR.

Gary E. Coen