

National Aeronautics and
Space Administration

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Reply to Attn of: DA8-86-52 (FT)

November 13, 1986

TO: Distribution
FROM: DA8/Chairman, Ascent Flight Techniques
SUBJECT: Ascent Flight Techniques Panel Meeting #25 Minutes

The 25th Ascent Flight Techniques Panel meeting was held at JSC on September 16, 1986. Rockwell-Downey and Draper Labs participated via teleconference.

1. Single Engine Roll Control for Out-of-Plane TAL - MDAC/R. B Henscheid

Mr. Henscheid presented a review of CR 89124 which addresses problems seen during single engine abort cases requiring out-of-plane maneuvering. These cases result in induced roll moments which could exceed RCS roll authority producing large roll errors and possible loss of control. The solution as contained in the CR would be to adjust the steering gains for the 2 main engine failure case. Reducing the acceleration command limits in the DAP maneuver smoother decreases the induced roll moments and significantly improves single engine controller performance. The cost of this improvement appears to be about 10 more seconds in the roll to heads up maneuver time. Presently this maneuver takes about 42 seconds but with the CR, about 52 seconds is required. Additionally, pitch axis maneuver time is increased somewhat, which may result in more altitude droop, possibly affecting early single engine abort boundaries. During the discussion of this item, additional concerns relating to ET heating and tank rupture were discussed. All of these concerns are presently being worked under existing actions to be concluded later this year. Also questioned was the quantity of propellant provided for single engine roll control and whether or not it was sufficient to cover all the possible cases. DM believes that the amount is adequate but will reinvestigate it.

Action: 11/16-001 - DM3/E. M. Henderson - Verify the single engine roll control propellant quantity is sufficient and covers all possible cases where it could be required.

2. Single APU Operation Protection for Ascent - MDAC/R. B. Henscheid

CR 89132 was also discussed by Mr. Henscheid. Study has shown that the loss of a second APU in first stage, which results in the lock-up of a side SSME, can result in nozzle collision, large attitude errors, and/or loss of vehicle control. The primary times of concern are during the roll maneuver start, the roll maneuver stop, and SRB tailoff with an SRB thrust mismatch ($\approx 200,00$ lbs). The CR proposed solution is to use the SSME out roll mixing gains when an engine is locked up and unparallel the side main engines in

yaw upon the first APU failure. Use of the SSME out roll mixing gains decreases the large attitude errors during staging, corrects steady state roll attitude errors in second stage and allows the vehicle to remain under control with three engines running longer in second stage. Unparalleling the side engines in yaw with the first APU failure eliminates the engine bell collision problem. It was also noted that in some cases we may need to shut down an SSME with a stuck TVC prior to a VI of 23K fps. With respect to unparalleling in yaw, an additional performance hit of about 600 lbs can be expected. The FDO's were asked to address how they account for the performance losses that result from engine unparalleling activities.

Action: 09/16-002 - DM6/C. D. Epp - Determine if the performance hit resulting from unparalleling engines needs to be accounted for and if so, how it will be implemented.

The process used to determine if the APU/HYD system is lost will be the same as that used in the priority rate limiting logic, and if sensed as failed, the logic will not reset if the system somehow becomes good again.

3. Auto Recognition of a Second ME Loss - DM3/D. L. Bentley, DF6/T. L. Stowe

Mr. Bentley reviewed the history of the request for this capability. The primary driver appears to be the single engine out RTLS with engine limits inhibited. Presently limits have not been re-enabled even when single engine completion capability (MECO minus ≈ 45 seconds) exists. If the second engine is lost, the crew must determine which one it is and use the engine shutdown pushbutton to tell guidance to enable single engine roll control. This procedure results in loss of control about 50 percent of the time due to Beta errors and the dynamic pressure seen by the vehicle. Mr. Bentley proposed three options, (1) implement auto recognition of a second SSME failure when limits are inhibited to automatically enable single engine roll control, (2) keep limits inhibited, accepting the risk of losing a second SSME and rely on quick recognition and response by the crew, and (3) re-enable the main engine limits at single engine capability. Ms. Stowe presented a story on two engine out cases and failures which would leave guidance trying to fly with two engine control with only one engine available. The consensus at the meeting was that we should go ahead and re-enable limits at RTLS single engine completion capability and pass that call up concurrent with the single engine call. Additionally, it was thought that we should take one more look at whether or not there is a way to safely automate the recognition of the second engine failure with limits inhibited and get single engine roll control. This has apparently been looked at before and there did not appear to be a satisfactory technique. Flying with limits enabled should greatly reduce our risk.

Action: 09/16-003 - MDAC/J. Compton, EH2/G. G. McSwain - Examine possible techniques to allow recognition of a second engine failure with limits inhibited to allow moding to single engine roll control.

4. Engine Loss Late on A 3 SSME RTLS - MDAC/R. B. Henscheid

Concerns have been raised by the Program with respect to the loss of an engine late (MECO-40 seconds to MECO) during a systems RTLS (three engines running). During this time period should an engine fail, guidance would still assume you were flying with 3 engines when in fact only 2 would be running. This situation results in a high H dot at MECO with possible implications on the GRTLS phase. Mr. Henscheid provided data on two proposed procedures to possibly alleviate the concerns. The two procedures investigated include keeping the engine throttles up at 104 percent at PPD or holding the flyback attitude until 10 seconds after the PPD flag. Early results seem to indicate that keeping the engines throttled up provided better results although there are still problems with trying to do this. Mr. C. Shapiro (Rockwell/Downey) also presented an early analysis which they had done on this subject. Their data seemed to indicate that there was no reason not to switch targets to reflect the engine out during the time period of concern. FM4/J. Pendergrass (MDAC) also presented some preliminary data on a quick look analysis on this issue. Mr. Pendergrass addressed both the throttling method and changing targets with the engine loss. It should be noted that even when staging with our present procedures, we exceed the Q bar separation limits. Further analyses will be performed on this subject as part of the launch abort assessment work, so we will be revisiting this item.

5. Dump Issues

Criteria for Last Systems TAL Capability - Deferred

Late TAL Targeting Altitude Relief - Deferred

Post-MECO TAL Selection Techniques - DG6/C. O. Lewis, Rockwell/T. Burk

Mr. Lewis presented data with respect to the need for a post-MECO TAL selection capability after reviewing our present procedures for a late TAL. The primary purpose of providing such a capability would be to aid the timeline and provide more time for OMS dumps. Mr. Burk presented several options for providing a post-MECO TAL selection capability. Current software does not permit a direct post-MECO TAL selection. The two techniques presented included making the TAL/AOA rotary switch position on the abort switch a TAL only abort selection valid either pre or post-MECO. AOA would just be an I-target entry. Redundancy for the TAL selection would still be provided by the SPEC 51 item entry. The other technique would be to separate the TAL/AOA rotary switch position into two positions, one for TAL and one for AOA and provide a similar capability on SPEC 51 for a backup. Selections on the rotary would then be RTLS, TAL, AOA, and ATO. Being able to set the TAL abort flag post-MECO would permit a number of things to happen which would speed up and simplify the timeline allowing possibly more OMS dump time. Mr. Burk pointed out that additional software changes would still be required to provide an auto maneuver to the TAL attitude and automate the OMS dump start at the MM304 transition. Crew representatives indicated that they never use the abort rotary switch to select an AOA but in fact just use the I-target load and that using the rotary switch position as a TAL only position should be acceptable. Flight Techniques concurred in the use of this technique provided the crew (CB) position was as stated and no other

technical show stoppers could be found. Given this, appropriate CR's should be generated for review by personnel working the OMS dump issues.

Action: 09/16-004 - CB/L. B. Hammond - Verify the CB position that using the rotary switch for pre and post-MECO TAL selection, with AOA selection capability available only as a target load, is acceptable, and whether or not redundancy in TAL selection via SPEC 51 should be required.

Action: 09/16-005 - EH3/D. H. Townsend - Provide a review of the software implications of using the rotary switch position for only TAL aborts and provide a CR to cover the required modifications.

TAL Post-MECO Roll Maneuver - Draper/T. Park

Mr. Park presented a preliminary proposal for a TRANSDAP auto maneuver modification for an automated high rate roll to heads up maneuver, again to aid the TAL abort timeline and provide more OMS dump time. Two approaches were proposed. A simple approach was discussed which just basically changed the maneuver rate from .5 deg/second to 5 deg/second for a TAL abort. While the implementation would be simple, there were a number of disadvantages including undershoot for a small maneuver, overshoots for large maneuvers, disturbance torque sensitivities, etc. A more complex approach would be to modify the TRANSDAP auto maneuver logic to be more like the on-orbit DAP auto maneuver logic. This would allow a recomputation of the maneuver angle and desired body rate each auto maneuver pass and would initiate the deceleration phase when the remaining maneuver angle is \leq the decel angle. This approach is a simple code implementation since it basically re-uses the maneuver initiation logic and solves the problems associated with the more simple approach. Mr. Park proposed further efforts to examine other potential issues. Flight Techniques agrees with the basic proposal involving the somewhat more complex approach and believes that this item should continue to be pursued with an appropriate CR being generated for review. Coordination should continue to be maintained with the dump mode team and EH.

Ops Need for Inhibiting an Automated MM304 OMS Dump - DF6/A. J. Ceccacci

Mr. Ceccacci presented the current MM304 OMS dump implementation. Dump operation now requires manual initialization for both dump start and the OMS to RCS interconnect. Additionally, a 4+X settling burn is performed before the OMS dump start and a CR has been approved to stop the OMS engines at .05g. Mr. Ceccacci proposed automating the OMS dump start at MM304 (2 engines straight feed) and adding logic for doing the RCS settling burn only if required. Manual initialization of the interconnect would still be required and an OMS engine check should be performed to terminate the dump (to cover the .05g concern). It was also proposed that a "dump stop" performed for any reason during a pre-MECO dump be carried across the OPS transition so the dump would not start automatically since we had to take action for some earlier engine anomaly. Given that this dump can be automated, a way to inhibit/stop it will be required. This information and proposal will be provided to the dump mode team for inclusion in their studies.

RCS Dump Issues - DF6/L. J. Hautzinger

Concerns were presented with respect to the amount of RCS propellant dumped during the 4+X RCS dump on a BFS TAL, a contingency 4+X dump, and the 270 second RTLS 4+X dump. Additionally, the six jets/pod during the 4+X dump issue was discussed. The primary concern over the dumps is based on SMS standalone and integrated simulations. Since the BFS TAL and the contingency aborts are flown manually, more RCS propellant is used and most times the dumps are stopped early to prevent running out of RCS during entry. The problem has also appeared when we use the 270 second dump on an RTLS. While there can definitely be some discussion on the fidelity of the SMS, the simulations have indicated a need to terminate the dumps early and on the day we really have to pull one of these off, there seems to be little doubt that we will do just that. DF requested that we I-load the 4+X dump to zero for the BFS TAL and contingency abort cases, and look at reducing the RTLS 270 second 4+X dump. Flight design personnel were asked to review these dumps to see what should be done and provide a recommendation.

Action: 09/16-006 - DM3/E. M. Henderson - Review the requested changes and provide recommendations at the next Flight Techniques meeting.

Additionally, DF reviewed the status of the issue relating to the number of RCS jets that can be fired simultaneously on a per pod basis. This issue is being carried as an SDRI issue and a response from Rockwell is expected. More work on this item will be required since it seems there may be an inconsistency here with respect to RCS 4+X dumps.

6. Delayed Post-MECO MPS Dump +X Translation - DM6/C. D. Epp

This item was deferred.

7. Onboard/Ground Downrange Landing Site Capability Display - DM6/B. D. Perry, CB/D. C. Hilmers

Mr. Perry and Mr. Hilmers presented concepts for determining abort capability (on the ground and onboard respectively) in contingency situations. Present procedures for this kind of situation use a cue card to select the proper runway and OMS/RCS configuration based on VI at MECO. Simulations have shown that this really is not an adequate method for determining the proper crew actions. Mr. Perry proposes a ground downrange abort evaluator (DAE) which could be used to provide the appropriate abort site based on such factors as Orbiter altitude, velocity, flight path angle, crossrange, and OMS dump configuration. Several methods of displaying the required data such as a site priority list, or an abort footprint may be studied. It is hoped that such a system might be ready for the first flight.

Mr. Hilmers proposed an onboard technique using onboard software to provide information on downrange and crossrange to a selected TAL site, and on the Orbiter "energy measure," which is seen as a single number which would be a function of a number of parameters (velocity, altitude, altitude rate, flight path angle, etc.). Use of this data and a cue card could give the capability to select the proper abort site and the proper OMS dump configuration. It is believed this technique would provide accurate and speedy insight into abort capability with a relatively small software impact. DM5/J. M. West stated

that they had been looking into possible techniques to predict downrange abort capability primarily using the "footprint type scheme" and that results looked promising. Flight Techniques supports the implementation of some type of downrange abort evaluator. Whether or not such a capability is mandatory for the first flight still remains a question, but we should be pursuing this as best we can. It is felt that the three groups looking into this capability should review the work of each so that a more consolidated technique be designed. If possible, the onboard and ground predictors should be same. If it is not possible to get an onboard capability, we still want it in the MCC.

Action: 09/16-007 - DM6/B. D. Perry, DM5/J. M. West, CB/D. C. Hilmers -
Review the proposed techniques presented to see if the desired requirements are being met with each, and provide a recommendation on the technique(s) to be pursued further.

8. TAL Crossrange Study - DM5/J. V. West

Mr. West presented a brief review of a possible problem concerning crossrange capability for the second engine out on a TAL case. There is concern since powered flight steers to a MECO state that leaves descent with about 500 nmi of crossrange to fly out. With the second engine out and the reduction in MECO velocity there is concern that we will not be able to cover the 500 nmi crossrange. Mr. West has established a working group to study the possible options to assure that we can reach the TAL site with the second engine out. Some of these options include automatically adjusting the crossrange in powered flight, targeting for a lower crossrange, and reassessing our TAL entry crossrange dispersion allowance. After the studies have been completed the results will be presented to Ascent Flight Techniques.

Presentation material desired for any of the items presented may be obtained by contacting DA8/W. W. Fink at extension 3051.


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