

National Aeronautics and
Space Administration
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Houston, Texas
77058

Reply to Attn of: DA8-86-36 (FT)

September 5, 1986

TO: Distribution
FROM: DA8/Chairman, Ascent/Entry Flight Techniques Panel
SUBJECT: Ascent/Entry Flight Techniques Meeting #23 Minutes

The 23rd Ascent/Entry Flight Techniques Panel meeting was held at JSC on July 31, 1986. Rockwell International-Downey participated via teleconference.

1. Post Touchdown Elevon Operations - EH2/M. M. Hammerschmidt

a. Elevon Positioning During Rollout - The engineering community was asked to examine all the options that exist and to recommend the optimum elevon position for rollout. Mr. Hammerschmidt presented an analysis which was performed to determine the gains that could be made in aerodynamic braking effect, main gear load relief, nosewheel steering, etc.

The study shows that maximum main gear load relief occurs with elevons full down during rollout. Main gear loads, particularly for a heavy weight vehicle (240,000 pounds), are much more severe for the full up elevon case than for full down. For full up, the force on each main gear is initially 190,000 pounds versus only 90,000 pounds with the elevons down (no wind). The problem is even more severe when considered with a crosswind (asymmetrical gear loading). See enclosure 1 for main gear and enclosure 2 for nose gear.

A gain in aerodynamic braking effect can be realized with the elevons up but not without subjecting the main gear to significant increased gear loads. The average reduction in stopping distance between full up and full down is approximately 775 feet with the maximum reduction being approximately 1500 feet. To get a feel for the relationship between improved stopping distance and increased gear load, Mr. Hammerschmidt identified "elevons up" corresponding to a 1000 foot rollout reduction results in a 90,000 pound increased gear load. The effect of raising the elevons after initial main gear loads have decreased has a minimal effect on stopping distance since drag is a function of the velocity squared. See enclosure 3.

In summary the full up elevon case (1) reduces stopping distance, (2) increases gear loads, and (3) increases the risk of blowing a tire. The impact to gear, brake, and tire margins remains to be examined in order to assess the total system gains associated with up elevon scheduling.

Concern: The engineering community was asked to investigate operational impacts of elevon scheduling on the main landing gear, nose landing

gear, brakes, and tires.

Action: 07/31-001 - EH2/H. G. Law, ES6/C. C. Campbell - Provide Flight Techniques the impact to main landing gear, nose landing gear, brakes, and tires for up elevon schedules.

b. Auto Load Relief Implementation - Current procedures for load relief implementation rely upon the pilot to hold the rotational hand controller (RHC) forward throughout rollout. Postflight analysis has shown that there is a tendency for the pilot to relax this pressure during the rollout. As a result, an auto load relief capability has been examined that will automatically configure the elevons in the 10 degree down position once the rollout discrete has been detected.

A change request (CR) is being written which will provide an auto load relief capability allowing transition from control stick steering (CSS) to AUTO automatically retaining the current load relief function within the auto pitch flight control system. At a specified time after the rollout discrete is set (0.5 seconds), the system will mode from CSS to AUTO. Inadvertent RHC "trip out" from AUTO to CSS is prevented by widening the pitch downmoding threshold from 6 degrees to 12 degrees. Entering auto load relief automatically (without crew action) will only be allowed once. If the pilot inadvertently trips the 12 degree threshold, AUTO mode will have to be manually re-selected using the AUTO/CSS pushbutton.

Mr. Hammerschmidt stated that the CR is complete except for Rockwell's work to implement the capability into the backup flight system (BFS) The stated purpose for providing this in the BFS was to reduce crew training, i .e. , the procedures would be the same for both the primary flight system (PFS) and BFS. This brought up the point that the BFS has always been a manual system and to provide it an auto capability would possibly have an adverse effect since the crew now knows that when in BFS everything is manual.

Concern: A CR is being proposed that would place an auto load relief capability within the BFS. The BFS has always been a manual system and to provide it an auto capability may possibly have an adverse effect since the crew is trained to take manual control if the BFS is engaged.
Action: 8/31-002 - CB/F. D. Gregory - Determine the Astronaut Office position on the relative merits of providing auto load relief capability in the BFS.

Response: Subsequent meetings with CB/F. D. Gregory confirmed the Astronaut Office's desire to support auto load relief in the BFS.

2. Flyable Y Center-of-Gravity (CG) Limits Given Orbital Maneuvering Subsystem (OMS)/Reaction Control System (RCS) Distribution Failures - EH2/M. M. Hammerschmidt

a. Aileron Trim Study - Mr. Hammerschmidt presented a study highlighting the factors which effect aileron trim and the ability of the vehicle to fly adequately with various Y CG offsets. The flight control system provides aileron trim by differential positioning of the elevons through a range of plus or minus 3 degrees. The study considered a full range of X CG, i.e., 1075 to 1110 inches, three y CG cases for 2, 4, and 6 inches and velocities of Mach 10.3 and 4.21. From the enclosed charts (enclosures 4

through 11) it can be seen that as the X CG moves forward, with any Y CG offset, more and more aileron trim is required to maintain equilibrium in the roll axis without the supplemental use of the RCS. This effect is caused by the reduced aileron effect due to the elevons moving out of the high speed aerodynamic flow as the flight control system positions the elevons up to compensate for a forward CG. As the CG continues to move forward more aileron trim will be required eventually saturating the elevon effectiveness for a range of Y CG offsets. From the charts it can be seen that for the Mach 10.4 case and the X CG equal to 1090 inches, saturation occurs with a Y CG offset of 6 inches requiring the RCS to maintain roll trim. For the Mach 4.21 case for the same Y CG offset the ailerons are almost completely saturated at all X CG ranges. Because of propellant consumption concerns it is not desirable to use the RCS for trim.

b. Trajectory Study on Fuel Usage - Mr. Hammerschmidt presented a study on the effects of Y CG on fuel usage assuming (1) nominal aero, (2) bent air frame, and (3) LVAR 19 aero. The charts (enclosures 12 and 13) show RCS fuel usage as a function of Y CG for a family of X CG ranging from 1077 to 1110 inches. Vehicle thermal constraints determine the required elevon schedule and body flap position for various X CG locations. The forward elevon schedule is used between 1089 and 1086 inches and the aft is used between 1089 and 1110 inches. For the nominal aero case with a Y CG of 7 inches and an X CG of 1086 inches, RCS usage is 5000 pounds. This is compared to 2000 pounds with an X CG of 1110 inches. The forward X CG position requires substantially more RCS fuel for entry with Y CG offsets greater than 4 inches. This is especially true in the test cases with LVAR 19 variations (reduced aileron effectiveness). Refer to enclosures 12, 13, and 14 for more information on the increased RCS propellant consumption as a function of X/Y CG.

c. Y CG Impact Due to OMS Tank Failure - DF6/L. J. Hautzinger presented the Y CG impact resulting from an OMS tank failure given a range of OMS propellant loads and representative OMS 1, 2, and direct insertion delta Vs. Using established flight rules as a guideline and assuming 250K weight, mixed crossfeed not available (leaking OMS), 90 degrees prebank, and forward reaction control system (FRCS) or aft reaction control system (ARCS) not available, the absolute worst Y CG expected using all of the good OMS propellant was 4.9 inches. The representative cases studied (enclosures 15 and 16) utilizing existing flight rules resulted in Y CG offsets ranging from 2.7 inches to 3.7 inches. Ms. Hautzinger also noted that use of the forward RCS and aft RCS for delta V purposes can provide a reduction in Y CG offset (approximately 1.2 inches).

These data combined with the identified increase in RCS propellant usage associated with Y CG offsets indicate that abort-to-orbit is a viable option for OMS tank failures during ascent. It appears that sufficient OMS delta V remains to perform an ATO (shallow deorbit) while still protecting RCS propellant redlines required to satisfy the increased entry control usage as a result of the Y CG offset. A final recommendation is pending the results of the bent air frame combined with LVAR 19 aero analysis.

6. Procedures for Ground Navaid Failures - TM2/R. D. Simpson

This agenda item was addressed due to a situation which occurred on a previous flight. Because of inadequate procedures, maintenance personnel powered

down a landing navaid to fix a problem without first obtaining concurrence from the flight control team. Mr. Simpson was asked to coordinate with the landing site facilities personnel to establish procedures for reporting and prioritizing landing navaid failure resolutions.

The procedure calls for an initial navaid status to be reported at launch minus 45 minutes on launch day and at deorbit time of ignition (TIG) minus 60 minutes on entry day. Any change in this status is to be reported by the on-site technical representatives to their respective interface, i.e., the ground operations manager (GOM) at KSC, the landing recovery director (LRD) at EDW, and the Northrup ground manager (NGM) at Northrup. The GOM, LRD, and NGM will then report to the landing support officer (LSO) who in turn reports to the flight dynamics officer (FDO). The FDO's interface will be the Flight Director and CAPCOM. For status and information flow from the flight control room to the landing sites, the reverse will be true.

If a landing navaid failure occurs at the transatlantic abort landing (TAL) site after L/O minus 45 minutes and is required to support weather minimums, the launch will be no-go. If the failure is in one half of a system and is such that it requires taking down the other half to remedy the problem, the "no MLS weather minimums" will apply until the system is restored. The requirement for microwave landing system (MLS) redundancy at the TAL site for TAL Go/No Go considerations was discussed without resolution. DA8/A. L. Briscoe agreed to accept the action to investigate MLS redundancy requirements at all TAL sites.

For the situation on entry day after deorbit TIG minus 60 minutes and prior to 30 minutes where it becomes necessary to take corrective action that affects the status of a landing aid, the LSO will be notified, and after receiving concurrence, the site will be allowed to take necessary action to restore the landing aid capability if it is predicted that the fix can be accomplished by landing minus 20 minutes.

For a failure that occurs after deorbit TIG minus 30 minutes the following corrective actions will be allowed after first receiving concurrence from the LSO:

- a. For a single MLS monitor failure, no fix will be initiated. No action is required because sufficient monitor redundancy exists (three monitors).
- b. For a single azimuth distance measuring equipment (DME) failure, action will be initiated to fix while maintaining continuous backup channel capability.
- c. For a single elevation channel failure, fix while maintaining continuous backup channel capability.
- d. For dual azimuth DME failure, fix (can not maintain backup channel capability).

For failures requiring continuous backup channel operating signal, loss of the backup signal will be cause for a deorbit wave-off if the MLS is required to satisfy "weather minimums." Further discussion Involved the risks associated with taking down a good MLS/system in order to regain a backup

capability and risk losing the good system. CB/F. Gregory preferred to have a known good single system than to risk losing the good channel.

Concern: If a landing navaid failure occurs at the TAL site after L/O minus 45 minutes in one half of a system and is such that it requires taking down the other half to remedy the problem, the no MLS weather minimums would apply until the system was restored. What requirements for MLS redundancy exist at the TAL site for this case?

Action: 07/31-003 - DA8/A. L. Briscoe - Determine if MLS redundancy is required to support launch requirements considering weather, day, night, and the landing site (TAL and return to launch site). Also consider end-of-mission sites.

Ronald D. Dittimore

Enclosures (16)