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TO: Distribution  
FROM: DA8/Chairman, Ascent/Entry Flight Techniques  
SUBJECT: Ascent/Entry Flight Techniques Panel Meeting #24 Minutes

The 24th Ascent/Entry Flight Techniques Panel was held at JSC on August 28, 1986. Rockwell-Downey participated via teleconference.

#### Summary

a. Up-elevon scheduling after nosewheel touchdown (NWTD) can produce excessive loads on already minimal tires/main landing gear margins. However, consideration will be given to scheduling up-elevon after NWTD at lower speeds if it can provide sufficient improvements in rollout braking. An action was assigned to evaluate this alternative.

b. Existing aimpoint locations will not be moved. Use of a portion of the KSC underrun will be investigated as an option for improving landing site "GO" probability. An action was assigned to verify load bearing capability of all landing site overruns/underruns.

#### Agenda Items

1. Up-Elevon Braking Impact to Landing Gear, Tires and Brakes -  
ES6/C. C. Campbell

Analysis revealed placing the elevons full up (30 degrees) at NWTD to increase braking effectiveness resulted in an increase in main gear loads of approximately 90-100,000 lbs. This translates into a 40-50,000 lb increase in individual tire loads.

Concern associated with already minimal main landing gear/tire load margins at touchdown has resulted in the desire to provide load relief through down elevon positioning at NWTD. Increasing the already unacceptable loads on the main gear/tires to increase braking effectiveness was concluded to be unacceptable.

Mr. Campbell stated that full up elevons result in unacceptable loads at NWTD but that some up elevon most likely could be accommodated. However, new testing would be required prior to approval.

Other unfavorable factors identified with up elevon:

- a. Unloading the nosewheel results in reduced nosewheel steering effectiveness.
- b. Tire failure response could be compromised with elevons in the up

position.

EH2/H. G. Law stated (and Mr. Campbell agreed) that it was likely that the elevons could be positioned up to provide aero braking once the high main landing gear/tire loads diminish during rollout. However, this would result in higher sustained tire loads. A software CR has been approved to provide auto load relief capability at NWTD that includes three brake points for elevon positioning. One brake point is used for load relief (down elevon) while the other two points could be used to schedule up-elevon for aero braking if the aero braking benefit is large enough. Mr. Law was given an action to study the relationship between the gain in braking effectiveness (in terms of rollout distance) and up elevon scheduling at lower vehicle speeds. The need to move the elevons to trail at wheel stop also needs to be discussed if up-elevon is selected.

Action: 08/28-001 - EH2/H. G. Law - Evaluate the relationship between the gain in braking effectiveness (in terms of rollout distance) and up-elevon scheduling at lower vehicle speeds.

Concern: It is desired to use up-elevon to increase brake effectiveness during landing rollout after NWTD. However, up-elevon imposes excessive loads on the main landing gear and tires that are already in a marginal load tolerant condition, especially at speeds associated with NWTD. Up-elevon may safely be introduced at lower speeds and may be worthwhile if there are sufficient gains in braking effectiveness.

Response: Minimal braking potential (<100 ft) can be realized utilizing the up-elevon braking technique due to violation of single tire load limits. (Reference Entry Flight Techniques Panel #25 minutes.)

2. Nominal Aimpoint Relocation - DM5/J. V. West, CB/S. D. Griggs, TM2/R. D. Tuntland

The aimpoint issue was identified as a result of a lack of transatlantic abort landing (TAL)/contingency landing site wind profile data (lack of adequate wind data increases risk of landing short of the runway) and the fact that 80 percent of the KSC and 22 percent of the EDW landings have used the high wind aimpoint. (Note that the runway underrun has not been considered when assessing the threshold margin.)

Mr. West showed data corresponding with 200 Monte Carlo runs that revealed 31.5 percent of the approaches, to a 12,000 ft runway landed short of the required 1,000 ft beyond the threshold. The Monte Carlo analysis assumed perfect nosewheel steering (NWS), short field technique, 25 kt tailwind/40 kt headwind altitude profile corresponding to the surface flight rule I limits of 10 kts tailwind and 25 kts headwind, and autoland guidance. All of the runs showed the vehicle stopping prior to 11,000 ft.

The same runs were repeated with the aimpoint moved in 1,000 ft resulting in only 10 percent of the cases failing to meet the 1,000 ft threshold criteria. However, much more speedbrake was required through touchdown.

The same runs were again repeated with the aimpoint in the current position, guidance selecting nominal or short field technique, and better wind data

below 3,000 ft. For these conditions, only 6 percent of the runs failed to meet the 1,000 ft criteria. Speedbrake requirements were nominal. It was noted that the 6 percent that failed to meet the threshold requirement were worst case cold day and winds. Only one case failed to make the runway. Moving the aimpoint closer reduced the 6 percent to 0.5 percent with only one case falling to meet the 1,000 ft criteria.

Crew concern centered around the increased speedbrake requirement associated with the close-in aimpoints. Although moving the aimpoint closer to the threshold does result in more energy control (speedbrake setting), the increased speedbrake setting results in a lift/drag (L/D) reduction that compresses the time to the target equivalent air speed (EAS). Currently, for acceptable tailwind cases, the 5 second point (i.e., 5 seconds prior to the targeted touchdown airspeed) occurs at approximately 20 ft altitude. With the proposed aimpoints, the 5 second point occurs somewhere between 40 and 60 ft resulting in increased sink rate in the last seconds prior to touchdown. In order to meet the touchdown velocity, an increase in touchdown sink rate could occur.

Summary of Advantages:

- a. 1,000 ft more protection (winds, bad site, aimpoint selection, off-nominal speedbrake, etc.)
- b. Increased launch probability.
- c. Increased energy reserves.
- d. Decrease in flight time after microwave landing system (MLS) elevation loss.

Summary of Disadvantages:

- a. Compressed timeline, crew work load, high sink rate.
- b. Cost: \$700K for aimpoint move.
- c. Marginal cost-benefit trade between better wind data and aimpoint adjustment. (With better wind data, only 1 of 200 cases failed to make the runway with current aimpoints. The one failure was a worst case cold atmosphere and winds. Pilot stretch techniques could improve the margin.)

CB recommended no change to existing aimpoint position. Improved weather/wind prediction capability will greatly reduce concern with landing short although it will not affect launch probability. Flight Techniques concurred. Since KSC is the long pole in the tent as far as causing a launch scrub for threshold margin criteria violation, some consideration may be given to using a portion of the underrun at KSC (1,000 ft) in the computation of adequate touchdown margin from "end-of-runway".

CB recommended that the load bearing capability of TAL runway underruns be verified for short landings. The action was assigned to Mr. Tuntland.

Action: 08/28-002 - TM2/R. D. Tuntland - Verify the load bearing capability for runway underruns/overruns at all approved landing sites.

Concern: Runway underruns could provide additional landing margin for Orbiter stretch cases where touchdown inside the threshold criteria is probable (i.e., low energy).

### 3. Dedicated Instrument Requirements - CB/L. B. Hammond

A CB survey was conducted considering all combinations of day/night entry and landings. CB presented the results of this survey as follows:

For Launch - All dedicated crew displays and related sensors must be fully operational at launch; AD], KS], AM], AVVI, and HUD (for night landings only).

For Orbit

ADI - IFM to regain two good forward ADI's. Enter next PLS for loss of two. Definition of a failed ADI is loss of 8-ball (no attitude info). However, IFM would be performed for loss of error needles on the first ADI. The ADI is needed for attitude information pre-MM305 or post BFS engage. No HUD information is available at this point and at high alpha the horizon is unusable.

Action: 08/28-003 - CB/L. B. Hammond - For loss of ADI or DDU where time does not permit completion of the IFM prior to the scheduled deorbit, determine CB position on requirement to regain ADI/DDU when the IFM results in deorbit delay (1 rev/1 day).

Concern: At present we do not have a coordinated position on the priority for IFM change out of ADI/DDU that could cause a deorbit delay.

HSI - For loss of 1 HSI, protect for a daylight landing and a no-MLS ceiling/visibility.

The HSI is the only source of raw NAV/TAC/MLS data for the outer glideslope (OGS)/inner glideslope (IGS) and is an essential cross check to verify course and glideslope commands.

AMI - For loss of 1, same as HSI.

The AMI is the only source of mach, EAS and alpha for landing. It is used to check ADTA validity.

AVVI - For loss of 1, same as KS].

The AVVI is the only source of information for altitude, altitude sink rate and acceleration. It also displays radar altimeter data which is critical to helping ensure touchdown limits are not exceeded.

HUD - Loss of 1, daylight landing only.

For a planned night landing, a spare HUD is onboard for IFM if required.

The HUD greatly eases the crew workload throughout approach, landing, and rollout and is an additional source of critical data (airspeed/

altitude/pitch angle/guidance). It is the only source of digital altitude and airspeed for use in the final stages of landing touchdown and rollout. Darkness adaptation is not a factor if the HUD is operational.

A software change is required to allow HUD operations in MM304. GNC was given an action to pursue the software change requirements (guidance marker and bank angle).

Action: 08/28-004 - DF6/H. J. Clancy - Investigate and pursue software changes required for NOD operations during MM304.

Concern: A HUD is required for night landings and CB has requested to have the NOD available for MM304 prior to TAEM primarily for bank angle information. A software change is required to provide HUD information in MM304.

CB stated their position against planned night abort/EOM landings. They are concerned with the increased risk of night landings associated with the elimination of visual cues. The question was raised as to the priority of landing at KSC in daylight or EDW at night. CB was given an action to determine a position on their priority.

Action: 08/28-005 - CB/L. B. Hammond - Develop a CB position on the priority of a landing at KSC in the daylight or a night landing at EDW.

Concern: Because of CB concerns with both KSC and night landings, a priority needs to be established for the case where deorbit is necessary and the options are KSC daylight or a night landing at EDW.

#### 4. Radar (Altimeter) Criticality - CB/M. S. Ivins

CB assigned the radar altimeter a CRIT 1 LRU because of their dependency on this source for proper sink rates during final flare at unfamiliar runways or during any night landing. For familiar runways, the radar altimeter was categorized as CRIT 2 (i.e., not required because of familiar surroundings of the runway).

CB further recommended two of two radar altimeter LRU's for launch based on the philosophy that all nav aids, primary avionics, and landing aids should be available for launch operations.

Loss of both radar altimeters is not cause for an abort or early termination of the flight because there is no requirement for this information on familiar runways.

Flight Techniques deferred comment on the CB proposal pending the review of MLS data versus radar altimeter data.

#### 5. MLS Alternative to Radar Altimeter - DM3/G. C. Kite

The GNC's attempted to relate MLS and radar altimeter data to determine if MLS derived altitude was an acceptable backup to the radar altimeter. MLS elevation is lost at approximately 50 ft resulting in the altitude rate decrease being determined by the IMU's, in the absence of radar altimeter

data, to the touchdown point. No measured data is available after 50 ft except radar altimeter. However, the question remains as to whether MLS NAV is an adequate backup to the radar altimeter for sink rate callouts. To resolve this question, DM and DF/GNC were given the action to compare radar altimeter, MLS and theodolite sink rate data. If the data compares favorably, MLS may be considered an adequate backup to the radar altimeter.

Action: 08/28-006 - DF6/H. J. Clancy, DM3/G. C. Kite - Compare radar altimeter, MLS and theodolite data to determine if the data compare favorably enough to consider the MLS data as a backup to radar altimeter data. Coordinate the development of this data comparison with CB.

Concern: MLS data is a potential backup to the radar altimeter and if usable could reduce the criticality of the radar altimeter.

#### 6. Orbit Capability with OMS Tank Fail - DF6/L. J. Hautzinger

Assuming worst case OMS tank failure, nominal MECO conditions, c.g., and LVAR 19 plus bent airframe, it was determined that orbit capability could be achieved and that sufficient ARCS was available to support an ATO and corresponding increased entry RCS usage. Both standard and direct insertion ascent cases were reviewed. Even with worst case Y c.g. offset of 4.9 in, sufficient ARCS was available to support a 2,200 lb entry usage case.

Far MCC operations, for loss of an OMS tank, increased ARCS usage must be accounted for when making the ascent press calls because of the associated X and Y c.g. Impact. It was not clear whether an AOA steep capability could be protected for the uphill cases and if the decision would be to continue toward ATO even if press-to-MECO would not be achieved. DM was given the action to review these cases and offer a recommendation.

Subsequent to the meeting, it was learned that turbulence had not been considered in the determination of RCS usage for large Y c.g. offsets. As this factor could dramatically impact RCS usage, a final recommendation from Flight Techniques will be deferred pending completion of the turbulence analysis.

Action: 08/28-007 - EH2/L. B. McWhorter, DF6/L. J. Hautzinger - EH2 should include turbulence effects in the Y c.g. RCS usage sensitivity data and provide this information to DF6 and DA8. DF6 will assess the impact of increased RCS usage, as a result of turbulence, on the capability of the OMS/RCS to support ATO.

Action: 08/28-008 - DM6/G. T. Oliver - Review OMS tank failure cases during ascent to recommend a proper action if AOA steep capability cannot be protected.

Concern: Although we have been able to show that we have sufficient ARCS to support an ATO, it is not clear that an AOA steep capability could be protected for uphill cases and if not, would we continue ascent toward ATO if AOA could not be protected.

Ronald D. Dittimore

