

TO: Distribution
FROM: DA8/Chairman, Ascent/Entry Flight Techniques Panel
SUBJECT: Ascent/Entry Flight Techniques Panel Meeting #54 Minutes

The 54th Ascent/Entry Flight Techniques Panel (FTP) was held at JSC on February 24, 1989. Rockwell-Downey and the University of Colorado at Boulder participated via teleconference. Any questions or comments should be directed to DA8/N. W. Hale, Jr. at 713-483-0693 or FTS 525-0693. The following items were discussed with the decisions made and actions assigned as noted.

Correction from January Ascent/Entry FTP minutes. Those minutes stated that the minimum angle-of-attack (α) to be flown for range stretch contingency cases was to be 34 degrees. This was based on preliminary analysis. Subsequent analysis has determined that the minimum limit is 37 degrees. That limit will apply to STS-29 and all subsequent flights until further analysis is completed.

Overall Summary:

a. The minimum safe perigee for direct insertion flights following an ascent performance problem will be 85 nautical mile (nmi) for low inclination and 90 nmi for high inclination.

b. There is a concern with noctilucent clouds that bears further investigation, particularly into the composition and size of the ice crystals in the clouds and the probability that those crystals would penetrate the Orbiter thermal boundary layer and cause tile damage. For the current time, flight design will avoid summer time high inclination descending node deorbit maneuvers. The unquantified risk associated with noctilucent clouds is low enough that descending node deorbit maneuvers in contingency situations will not be precluded. Missions with a requirement to risk flying through a noctilucent cloud should be evaluated on a case by case basis.

c. Ames VMS study shows that the current KSC crosswind flight rule limit of 10 kts is very safe from the tire wear standpoint and there is hope to raise the limit based on the results of the crosswind DTO.

d. With the modifications to the WOW electronics, landing rollout analysis required to give a GO/NO GO for a particular runway will be based on 100 percent braking capability rather than the 50 percent limit in the current rules. This is a CIL item change and will be presented to the PRCB.

e. Edwards Lakebed runway testing has demonstrated that the three primary STS runways are acceptable but required continued surveillance. Improvements in testing and runway repair have been recommended, as well as analysis of the load bearing capability of the shoulders of (concrete) runway 22.

f. Abort boundaries and ascent performance data for STS-30 are greatly affected by launch time due to the changing planar requirements.

Detailed Minutes:

1. Action Item Closeout

a. 88/01/15-004: Elliptical Orbit "Anytime" Deorbit Capability - DM3/E. P. Gonzalez. The desire was to demonstrate that dispersions in propulsive consumables would help close large gaps in emergency landing site (ELS) coverage in elliptical deorbits. Since night landings at ELS are not acceptable, there are currently forecast to be gaps greater than 4.5 hours. However, with the upgrade of Anderson AFB, Guam, and Hickam Field, Hawaii, to augmented contingency landing site status that allows night landings, many of the gaps will be closed. The study of propulsive consumables revealed that in most cases they would not close the gaps. The action is closed. Elliptical orbit contingency deorbit gaps are being largely eliminated by the upgrading of two Pacific Ocean landing sites; propulsive consumables dispersion allocation will not solve the problem.

b. 87/80/28-003: Minimum Safe Perigee Altitude (Hp) for Post-STS-26 Flights - DM/C. W. Sparks. This study was initiated primarily for the purpose of delineating options for ascent performance problems and day 1 and 2 deorbit capability. The minimum Hp is driven by primarily by the uncertainties in the drag models at perigees around 80 nmi. The work that has been done for direct insertion flights indicates that the minimum safe Hp for 28.5 degree inclination flights with all apogee altitudes (Ha) greater than 105 nmi is 85 nmi. For 57 degree inclination for Ha between 105 nmi and 240 nmi the minimum safe Hp is 90 nmi. At higher Ha orbital precession may not allow deorbit at the required time on day 2, so flight specific analysis will be required. Standard insertion data is in work and will be presented in March. Data for 63.5 degree inclination is not part of this action but will be studied for the generic 63.5 degree inclination work which flight techniques will address in April. The action is open and will be rescheduled for the March FTP meeting.

c. 88/12/12-001: Aft RCS Tank Constraints for Late Second SSME Failures - RI-D/FC94/J. S. Yasuhara. From the December (#52) Ascent/Entry FTP discussions of forward RCS single main engine roll control propellant requirements (ref. DA8-88-96 (FT) item #6) it appeared that the aft RCS was excessive. Analysis presented at this FTP meeting showed that the propellant used and the acceleration angles experienced do not exceed aft RCS tank limits and therefore there is no problem. A software change (CR 89635) which would allow additional usage of the aft RCS for these cases still would not cause violation of the constraints. The action is closed.

d. 87/10/30-002: Cabin Depress for Broken Window Pane - DF7/P. J. Cerna. ES2/K. S. Edelstein represented the engineering community in stating the requirement for the depressurization. The action was assigned primarily to deal with loss of both thermal and center pressure panes during ascent. Mr. Cerna presented a procedure that is workable with minimal risks. The use of cabin vent valves is not allowed due to a single point catastrophic failure (power supply to close the valves), so the airlock depress valves will be used. With the launch escape suit (LES) visors open, which terminates oxygen flow through the suits, the partial pressure of oxygen can be controlled in a safe (less than 30 percent) range. A discussion of the need to close visors for a different scenario, that of the inner pane shattered, ensued and it was determined that this procedure was not acceptable; the LES visors must be closed to prevent ingestion of floating glass particles and this prevents

proper control of oxygen concentration. However, the action item and procedure were designed for loss of integrity of the center pressure pane which is not a glass ingestion problem, therefore the action is closed.

2. Noctilucent Cloud Followup - DM3/J. V. West

This presentation was an update to the discussion presented at Ascent/Entry FTP #43 May 1988 (ref. DA8-88-52 (FT) item #3). With the inclusion of Dr. Gary Thomas of the University of Colorado at Boulder, the picture is becoming clearer. Dr. Thomas tracks the noctilucent clouds with satellite pictures and had some conclusions: first, outside of the summer months they are virtually non-existent; second, even during the peak season of June 1 through September 1, the frequency of occurrence of the clouds in the 50 to 60 degree latitude band is only about 10 percent; up to 65 degrees it is only 20 percent; (although at near polar latitudes they are 100 percent). From a meteorology point-of-view ice particles greater than 1 micron in diameter are very rare, less than 1 per cubic centimeter -- however, from a tile erosion standpoint that is an unacceptably high concentration. Dr. Thomas described a sounding rocket campaign to take place in the summer of 1990 to better characterize the composition of the clouds. Action Item 88/05/26-001: Define the Particle Size in Noctilucent Clouds, is considered closed with the available data.

Data was presented showing that the vehicle response to the density shear associated with cloud penetration was survivable.

Action Item 88/09/26-002: Noctilucent Cloud Penetration Survivability - VF5/D. A. Gerlach. Based on an engineering judgement assessment, the Orbiter Project determined that noctilucent cloud particle size, density, and thickness would scrub the Orbiter of its thermal protection system (loss of all black tile coating and the reinforced carbon-carbon). Possible loss of vehicle would result. A more definitive study was recommended. This action is closed.

The conclusion of the FTP is that there is a concern with noctilucent clouds that bears further investigation, particularly into the composition and size of the ice crystals in the clouds and the probability that those crystals would penetrate the Orbiter thermal boundary layer and cause tile damage. For the current time, flight design will avoid summer time high inclination descending node deorbit maneuvers. However, the perceived (and unquantified) risk associated with noctilucent clouds is low enough that descending node deorbit maneuvers in contingency situations will not be precluded. Further, if a payload has a significant reason to require a mission profile that incurs the risk of flying through a noctilucent cloud, that should be evaluated on a case by case basis.

3. Discussion of Atmospheric Density Shears and Affect on Angle-of-Attack During Entry - DM3/RSOC/R. T. Silvestri

Density shears which affect Orbiter autopilot controls are common and have occurred several times to date. These have caused significant pilot concern with the consideration of manual takeover. This presentation showed that manual takeover is not required in this frequently encountered real world situation. Crew training is required to thoroughly familiarize pilots with the signatures of autopilot response to density shears (see enclosure).

4. Orbiter Drag Chute

- a. Overview of Design, Testing, Installation
- b. Flight Software Impacts
- c. Flight DTO Plan
- d. Procedures Impacts

ES6/J. J. Kennedy gave an overview of the purpose, design, and schedule for the drag chute system. The system consists of an automatic repositioning of the main engine bells at about the Mach 8 point, manual chute arm/deploy by the crew using switches located beside the head up display (HUD) at main gear touchdown (MGTD), a pyrotechnic mortar removing the chute door, firing a pilot chute which pulls out the main chute which is initially reefed, then manual crew jettison action by a switch next to the HUD at about 40 kts on rollout. The system is scheduled to first fly on STS-54 and would require OI-21 software support. Discussion by the panel centered on: (1) the requirement to move the main engine bells and the associated complications; (2) deployment techniques; and (3) jettison systems.

Of particular interest is the chute release mechanism. If the chute is inadvertently deployed at speeds above about 230 EAS, it will break away in a manner similar to the jettison normally accomplished during low speed rollout. The breakaway/jettison is a soft release in the sense that no metal parts are jettisoned, only the "soft" kevlar chute riser straps. The center main engine bell must be repositioned to a full down position to preclude impact with the chutes on deployment and jettison. Such an impact would not damage the chute or prevent its proper operation, but would likely cause damage to the engine bell.

DF6/J. P. Shannon discussed deployment techniques with the clear indication that significant work will have to be done in this area. Of particular interest is that there is an area of angle-of-attack instability between 4 degrees and zero degrees positive pitch during derotation where chute deployment should be avoided. Also discussed were aspects of the engine repositioning software. The down position of the engines does not correspond to rain drain, so postlanding repositioning is still required. There was some discussion on the nature of rules and procedures to be written to define the failure scenarios that would result in no engine repositioning. Whether or not the drag chute would be deployed with no engine repositioning will also have to be defined. There is only a single instrumentation point on each engine indicating position of the engine bells and work will have to be done to cope with failure of that instrumentation.

DF4/P. A. Bacala gave an excellent overview of the expected operational impacts for drag chutes (see enclosure).

5. 1988 Ames "KSC" Tire Wear Results - EH2/H. G. Law

Mr. Law presented the results with the revised tire wear model and smoothing of the touchdown zone. The crosswind results are not directly comparable to the flight rule limits since the turbulence (gust factors) are not the same. The vertical motion simulator (VMS) results showed that with a 15 kt cross wind (18 kt peak with gusts) the three sigma tire wear just exceeded the 4 cord wear through limit. Since the flight rule KSC limit is 12 kts peak gust

limit and some handling quality concerns, the VMS results give hope for raising the crosswind limit if the crosswind detailed test objective (DTO) is successfully carried out. The cord wear at 10 kts (13 peak gust) on the VMS was less than 1 cord.

6. Review of Single Point Failures that Result in Loss of Braking Capability - DF4/B. W. Irlbeck

Mr. Irlbeck reviewed the results of modifications to the weight-on-wheels (WOW) electronics. These modifications eliminated the last credible (non-structural) single failure that could cause loss of 50 percent braking. Since failure scenarios to reduce braking are multiple failures, or structural failures, or have less impact than the brake energy limits; the FTP recommended that flight rule 4-62 defining the pre-entry analysis limits for runway site selection delete section b. which allowed use of only 50 percent brakes. Since this is a critical items list (CIL) impact, Systems Division will present this change to the Program Requirements Change Board (PRCB).

8. No FRCS ET Separation Procedure with ET Tumble Valve Inhibited - DF6/S. J. Elsner

Since the NSTS Program is considering inhibiting the external tank (ET) tumble valve (a CIL criticality 1 item), and the current crew procedure to separate from the ET following total loss of the forward RCS assumes tumble valve operation, a new procedure has been devised. This new procedure is not to be considered for STS-29. The procedure is enclosed. The proposed procedure was defined by RI-D/FC94/C. W. LaMont and has been in existence for some time. Preliminary analysis by the Guidance and Control Section appears positive; however, clearance analysis needs to be performed and submitted to the FTP.

ACTION: 89/02/24-001 - DM3/G. L. Norbraten - Present clearance analysis of proposed no FRCS ET separation procedure with ET tumble valve inhibited to Ascent/Entry FTP at the April meeting.

9. FRCS Maximum Loading (STS-27 Regulator Failure Follow up) Quantity and Duration of Placard - DF6/R. D. Jackson

Mr. Jackson presented the preliminary failure analysis showing that a Belleville cracked causing sluggish regulation in the oxidizer regulator of the right aft RCS. This is not the generic contamination sense port blocking that was the cause for FRCS offload for the first two flights of each Orbiter (ref. PRCB PCIN #40767A). Therefore, there is no need to require extension of the offload requirement. However, the flight design community will continue to offload the FRCS on all flights where a full load is not mandatory; the first flight where a full load is mandatory is STS-39 (IBSS) with the cycle 1 flight design due this June.

11. Alternate Elevon Schedule Design - RI-D/FB98/D. W. Pearson

Mr. Pearson stated this subject only. For STS-29 the main engine nozzles will get extra insulation but the limit is still exceeded so a waiver is required. Preliminary data indicates the window for the use of the mid schedule shrinks but is not eliminated. Rocketdyne is updating heating

limits for the main engine nozzles which should reduce the concerns. This topic will be rescheduled for the March Ascent/Entry FTP.

12. Bermuda Performance Boundaries - Sequential Engine Out -
DM3/D. L. Bently

Mr. Bently presented the preliminary abort windows and ET impact footprint. These limits were based on offline simulations with 3 g pullouts. Sequential engine out cases give Bermuda boundaries from about 340 seconds in flight (inertial velocity of about 9070 fps) to the droop boundary of about 425 seconds and about 11,200 fps. The droop Amilcar boundary was proposed as the limit for the Bermuda case even though performance would still allow the Orbiter to reach Bermuda for a short period after droop. The rationale to continue on is threefold: first, the crew has had almost no training in the Bermuda procedure, second Bermuda is not in the onboard site table and must be uplinked, and third the droop case avoids a high g pullout. The FTP concurred with using the droop boundary as a limit for Bermuda. The ET impact footprint is very well clear of Bermuda (see enclosure).

13. IRAMS Limits

a. Generic vs Flight Specific - EH5/M. E. Jones

Mr. Jones described the plan to develop generic equations for any given launch azimuth and landing site. This study should be complete this summer and then only vehicle mass properties will affect the hold time. Missions with ground up rendezvous (STS-32) will require further work. Changes to the software coming with OI-8C (October 1989) will alleviate some redline concerns.

b. STS 30 Deltas for Weight and CG - DF6/D. E. Miller

Mr. Miller presented the flight specific redlines. For STS-29, the no-IRAMS unplanned hold time limit was analyzed to be 180 minutes. Preliminary analysis indicates the same limit will be usable for STS-30 but that work is still in progress.

14. Lakebed Testing Program - CB/G. L. Kratochvil

Mr. Kratochvil gave the FTP essentially the same presentation that Level II heard a week earlier when funding was approved for the spring 1989 testing program. The origin and nature of the fissures was described as well as the problem with soft lakebed material in general. From the STS 61-A tow problem it is clear that when the material is softer than California Bearing Ratio (CBR) 20, then the Orbiter will have a problem. The severity of the problem depends on dwell time over the soft spot (e.g. during the high speed portion of rollout there will not be a significant problem), weight on the wheels (reaches a max during nosewheel touchdown and load relief), and lateral extent of the soft spot (e.g. if a fissure is less than about 24 inches wide hard material on either side would support the Orbiter). Of concern is the fact that the fissures and resulting soft spots do not cross lakebed runways with a consistent pattern. If the radar does not detect them at the one swath 10 feet from the centerline that is currently done, there may still be a problem at some different distance from the centerline.

From a purely structural standpoint, the lakebed runway priorities ought to be 17, 15, 23. However, since 15 does not significantly change the wind direction that would cause a change from 17 and only enough landing aids are available for two runways, so the runway priorities in the flight rules remain 17, 23, 15. Landing aids make a runway higher priority than hardness. 23 may be soft, but it is hard enough to be acceptable.

By request from the FTP, testing this spring will also look at the runway shoulders to EDW 22 concrete runway. While it is not on the lakebed the material is similar. The shoulders are cleared for 300 feet on either side of the 300 x 15,000 ft runway. If the shoulders are as hard as the lakebed, then EDW 22 would be the clearly preferred landing site.

15. STS-30 Flight Design Overview - DM3/T. H. Robertson

Mr. Robertson gave a discussion of the planar window requirements for STS-30 (Magellan). Since the desired plane is 28.85 degrees, the yaw steering and performance varies during the launch window. There is minimal performance margin early in the window and a discussion of launch hold issues brought up several topics that will be readressed at the March Ascent/Entry FTP. Near the close of the window, Ben Guerir TAL capability is lost. Boundaries are included in the enclosure. Four alternate I-loads for day of launch winds aloft have been defined. OMS 1 and 2 targets were presented as well as ET disposal for underspeeds and AOA landing opportunities.

Deferred to March FTP:

7. Alpha Stretch Vehicle Differences - ES6/D. Curry

10. The Selection of Effects of Alternate Rev Descent on SSME Nozzle Heating
- RI-D/AC78/R. J. Robinson

STS-27 Tire Leak Lessons Learned - ES6/C. C. Campbell

Aft RCS Entry Redlines Update - EH2/M. M. Hammerschmidt

OMS Dump Interconnect On/Off Study - RSOC/R16B/M. Fatehi

The next Ascent/Entry FTP meeting is planned to take place on March 17, 1989, at JSC in building 29, room 109.

Original Signed By:
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Enclosure