

DA8-90-05 (FT)

January 11, 1990

TO: Distribution

FROM: DA8/Chairman, Ascent/Entry Flight Techniques Panel

SUBJECT: Ascent/Entry Flight Techniques Panel Meeting #60 Minutes

The 60th Ascent/Entry Flight Techniques Panel (A/F FTP) was held at JSC in four parts on September 8 and 22 and October 6 and 10, 1989. Rockwell-Downey participated via teleconference for the first three sessions. 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.

Overall Summary:

a. A new study of RCS propellant usage during entry with improved atmospheric and turbulence models has been accomplished. Propellant requirements are a function of inclination, with a redline of 1100 lbs for 28.5 degree inclination flights and 1300 lbs for 57 degree inclination flights required to cover 3 sigma usage between EI and Mach 1.

b. Temporary wind instruments are in place at Edwards for the near term and work is in progress for a long term solution to the landing wind instrumentation problem.

c. Guam and Hawaii are virtually ready to support shuttle landings as augmented emergency landing sites.

d. The FTP recommends that the improved weight-on-wheels (WOW) system utilizing wheel speed sensors be incorporated along with the new hydraulic landing gear deployment isolation valve. WOW should then be the point at which hydraulics pressure is supplied to the brakes.

e. For the general STS entry, a single vent door failed closed acceptable.

f. Preliminary studies indicate low angle-of-attack stretch cases for due east missions may use the 37/31 profile.

g. New structural limits for contingency aborts have been provided and procedures development is in progress to determine what improvements can be made in contingency aborts. Preliminary reports from crew training indicate that trainees have a good rate of success in completing existing procedures.

h. SSME statistics are evenly divided between the number of cases where the redline sensors prevented catastrophe and where the engines would have continued to run and thus not required an abort/ditch/etc.

i. The Convair 990 program to test tires, brakes, and landing gear is in progress with the first test flights in November 1990.

j. Because of structural concerns, the FTP recommends that for STS-32, if SYNCOM cannot be deployed, LDEF should not be retrieved. For downstream super heavyweight landings (248k TAL, 256k RTLS), significant work remains to be done to determine landing gear, brake, and tire capabilities.

k. STS-28 suffered early unsymmetrical boundary layer transition from

tile gap filler misalignment. This cause slightly higher than usual RCS usage but still less than the 3 sigma redline. The flight control system (FCS) worked properly with no unexplained anomalies.

l. MPS dump delta velocity contribution on direct insertion flights has been planned to be 8 fps and has actually been 11 to 13. The flight design process should plan for 11 fps.

m. A working OMS tank screen model is available for post-MECO dump time determination. Model results show that good dumps can be performed in the 3 EO RTLS blue and 3 EO CA green regions. Model results also show the late TAL dump time should be based on 20 percent OMS quantity remaining.

n. The way in which propellant ballast is currently allocated in the press-to-ATO calls is considered to be too conservative; a study should be initiated to determine if it is acceptable to RSS the following items (when converted to equivalent values such as second of press time): 2 sigma MPS variation over the nominal; 3 sigma RCS entry usage over the nominal; and the propellant required to protect the 3 sigma dispersions on the CG box.

#### □Detailed Minutes

The first meeting of the 60th A/E FTP took place on September 8, 1989, at JSC in building 29, room 109 with Rockwell-Downey participating via teleconference.

□Walk-On #1□: Flutter Buffet DTO 309 - WE2/R. O. Wallace, RI-D/FB98/  
D. W. Pearson

Mr. Wallace and Mr. Pearson gave the background on this DTO to close out some confusion that was generated at the 59th A/E FTP on this subject. The DTO must be done on OV-104 as it is the only vehicle that is properly instrumented. The DTO requires a max qbar in the 700 to 730 psf region from Mach 1.0 to 1.3 to evaluate the flutter boundaries on the aero surfaces. Currently STS-41 is being designed to achieve this max qbar; other flights are limited to lower values. However, there is a possibility that on any flight, dispersions could drive the qbar to the DTO level. Therefore, the engineering community has requested that the structural programmed test inputs (SPTI's) be enabled prelaunch for all OV-104 flights. The software exists in OI-8C and subsequent releases. What the software does is to excite the elevons and rudder (but not the body flap) at very low amplitudes but high frequencies. The responses are so small that they cannot be detected by the crew or flight control team. If a main engine failure occurs, the SPTI's are automatically inhibited. There are no other reasons to inhibit the test.

A concern with the SPTI's is the STS-28 body flap anomaly. If the body flap is cleared for flight, the A/E FTP sees no reason why the SPTI cannot be performed on STS-34.

1. □Action Item Status

a. 86/08-003: Aft RCS Entry Redlines - Update from New Aero Data Base Including Turbulence - EH22/M. M. Hammerschmidt - The new analysis ground rules had been reviewed by the A/E FTP previously, it includes a new more realistic turbulence model developed by MSFC. The analysis was run in batch simulation mode on the SES with the OI-8B flight software; a nominal EOM set of trajectories from EI to Mach 1, the FAD 26 aero data base, the GRAM 4-D global atmosphere model, 200k and 240k lb orbiter weights, 28.5 and 57 degree inclinations (the 57 degree entries were winter descending deorbits -- the worst case from atmospheric uncertainty), y cg offsets of up to 2.0 inches, actual x cg's from 1075.0 to 1110 with all three elevon schedules selected to 1 inch outside their normal ranges. There was a random turbulence model, a set of 100 random atmospheres for each inclination, and random aerodynamic uncertainties including boundary layer transition.

The turbulence models most affect the forward cg cases, so it is not surprising that the new, less severe, more realistic turbulence model gives lower RCS usage for forward cg cases.

The data (see enclosure) show that the usage is not a strong function of weight or cg, but does seem to be a function of orbital inclination, with the uncertainties in the atmosphere at higher inclination leading to higher RCS entry usage than at lower inclinations.

The mean usage for 28.5 is between 600 and 800 lbs; for 57 it varies from about 700 to 900 lbs. The mean plus three sigma dispersions usage for 28.5 varies from 850 to 1125 lbs; for 57 it varies from 1100 to 1375. It was felt that these numbers were overly conservative with systems dispersions stacked together. After much discussion the A/E FTP decided that the appropriate redlines would be 1100 lbs for the 28.5 degree inclination flights, and 1300 lbs for the 57 degree inclination flights.

□Action: 89/09/08-001□ - DF6/A. J. Ceccacci - Submit changes to the Flight Rules and Flight Design Groundrules documents to incorporate RCS entry (EI to Mach 1) redlines of 1100 lbs for 28.5 degree inclination flights and 1300 lbs for 57 degree inclination flights, effective for STS-33 and subsequent.

The A/E FTP determined that the 57 degree atmosphere would cover the 63.5 degree inclination; no further study was warranted. However, the question is open as to where the atmospheric breakover between the 28.5 degree and 57 degree inclinations occurred.

□Action: 89/09/08-002□ - DM3/J. H. Siders - Determine orbit inclination where the atmospheric breakover point occurs so that the appropriate RCS entry redline can be used.

b. STS-34 IUS/Galileo Return Thermal Issues - ES32/R. G. Brown - This item was not discussed during the FTP meeting but following the meeting Mr. Brown provided analysis (enclosed) that demonstrates that the ASE Y-damper thermal concern that was left open from the A/E FTP #58 is not a problem.

## 2. □STS-32 Ascent/Entry Overview

a. Launch Window - RSOC/R16H/A. T. McDowell - The cycle 2R launch window opens on December 18 at 23:46 GMT (5:46 pm CST) with dark RTLS, TAL, AOA but daylight EOM. The launch window opens 49 minutes prior to the LDEF in plane time and closes 60 minutes after it opens. The launch window is highly complex on this flight depending upon such variables as LDEF orbital altitude at launch time and amount of propellant that may be committed to the rendezvous (e.g., length of mission, LOX drainback hold time, etc.). The ends of the window are also driven by ET impact with the earliest time limited by ET impact near Palmyra (south of Hawaii) and the latest by ET impact near Hawaii.

b. Ascent Design Summary - DM32/C. W. Fraley - STS-32 will be a direct insertion to 190 nmi, 28.5 degree inclination, October mean winds (launching in December-January). With the expected winds the ascent performance varies through the window with 529 lb margin at window open and 1939 lb margin at the in-plane time. With baseline and eight alternate I-loads for first stage, the launch probability from the performance and structural loads standpoint is 79 percent. The ATO dump will be performed with the inter connect enabled since the OMS loading is so large. Three ascent DTO's have been scheduled: 236 ascent wind aerodynamic distributed loads verification on OV-102, 301D ascent structural capability evaluation, and 312D ET TPS performance. The first two have no real-time operational impacts; the last is the well-understood and frequently performed ET photography procedure.

c. Unique Aspects of STS-32 Ascent - RSOC/R16B/M. R. Grabois - On the crew OMS-1/2 targeting charts, three abort trajectories are limited by the 55 nmi minimum altitude constraint: ATO/AOA-ST, ATO/MIN HP, AOA-SH/AOA-SH. This means that there may be a window where late TAL may be required rather than a low altitude uphill procedure. The ATO/MIN HP (85 nmi) covers AOA-ST. The crew must also adjust the tig times since the orbital plane varies with launch time; this is a well established procedure. Variable IY is enabled for about a 20 second period for launch at the beginning of the window. This gives about a 6 second earlier press-to-ATO; with later launch time (nearer to in-plane) the advantage is lessened. The design underspeed is 290 fps to protect the east coast of Africa. Underspeeds of up to 900 fps can be supported for no dump cases (AOA critical) but NPSP is violated with underspeeds greater than 500 fps.

□Action: 89/09/08-003□ - RSOC/R16B/J. D. Tinch - Provide A/E FTP briefing on the options to increase underspeeds to the NPSP limit or greater.

d. STS-32 Abort Boundaries - RSOC/R16B/B. A. Picka - The abort boundary charts are included; good coverage exists for TAL to Ben Guerir and Moron, Zaragoza was not analyzed for cycle 1 but information will be provided later. The opening of the boundaries does not change much with launch hold, however, early in the launch window Moron closes prior to PTM (but later than PTA). The single engine stuck throttle analysis shows that there is no uphill capability below about 70 percent.

e. STS-32 On-Board Plane Control During OMS-2 - RSOC/R16B/E. L. Bently - Onboard software provides for OMS-2 plane change control for rendezvous inertial targeting. It can be mathematically demonstrated that out-of-plane corrections can most efficiently be made during OMS-2. If the AOA or ATO flags are set, this software is automatically disabled. OMS budgeting allows for 1196 lbs of propellant to cover out-of-plane errors accrued during a 62 minute launch hold (greater than the window) or up to 165 fps MECO under speed.

f. STS-32 Deorbit Opportunities - DM3/E. P. Gonzalez - The opportunities for cycle 2R are enclosed. Many of these opportunities are at night and the crew is trained in night landings; however, the primary EOM is daylight.

g. STS-32 Entry Overview - DM3/K. D. Walyus - The mass properties are enclosed, for nominal EOM the weight technically violates the limit by 121 lbs, the x cg is 1082.1 which requires the forward elevon schedule and the heavyweight glideslope. Also, for derotation concerns, concrete runway is recommended. For the first time since the return-to-flight programmed test inputs (PTI's) are scheduled for entry.

h. STS-32 Landing DTO and Runway Priorities - DA8/N. W. Hale - DTO 0805 crosswind landing evaluation has the highest priority. The high speed and then low speed version of DTO 0517 nosewheel steering are next in priority. Multiple DTO's will not be performed on the same landing, nor will they be performed at night. NOTE: Subsequent to this FTP meeting, concerns with landing loads has caused cancellation of all landing DTO's for this flight; concrete runway landing is required.

i. LDEF Thermal Conditioning for Entry - DH64/J. A. Larson - Most of the LDEF constraints are for mission success. The safety related thermal constraints have to do with LDEF trunnions and batteries; the time in -ZLV is unlimited, -Z to space is limited to 15 hours with an equivalent amount of -ZLV required before entry, and -Z to the sun is limited to 14 hours with -ZLV required 1.5 times as long for conditioning. For mission success, there is a series of attitudes to cold soak LDEF that are primarily starboard side not in the velocity vector, culminating in a -ZLV nose north attitude. Review was performed of Flight Rule Annex rules A5-20 post-berthing thermal conditioning, A5-21 excursions during thermal conditioning, A5-21 excursions during thermal conditioning, A5-22 nominal thermal constraints (post conditioning), and A5-23 safety thermal constraints. All these rules appear to be complete, well documented and thorough with no changes recommended.

Mr. Larson also stated that there are no thermal constraints on SYNCOM for contingency return.

j. LDEF Thermal Conditioning Attitudes - DH4/D. G. Hord - Ms. Hord gave a pictorial overview of the pointing required.

□

3. □Prelaunch IMU Drift Compensation on STS-32 Ground Up Rendezvous□ - DM3/B. K. Joosten.

This item was deferred to the September 22 meeting.

4. □Manual Throttle for NPSP Limited Underspeed Flights□ - DM3/B. K. Joosten

This item was deferred to the September 22 meeting.

5. □Status of Wind Instrument Improvements□ - MJ/L. J. Penn

Included in this presentation is a copy of the MOD requirements for operational wind measurements to enhance safety as well as to provide the necessary information to analyze the results from DTO 0517 crosswind landing evaluation. All the existing wind towers on the lakebed at Edwards AFB have been calibrated and the long term calibration and maintenance plan has been established. There are two 30 foot portable towers in place from White Sands Missile Range (WSMR) for temporary use starting on STS-34 until such towers can be bought for permanent use at Edwards. Work is underway to establish the data links to automatically transmit the information to JSC. Finally, Mr. Penn asked for inputs on the type of new instrumentation above the existing needs on the new towers to be purchased.

6. □Concept of Operations for Hickam AFB, Hawaii, and Andersen AFB, Guam□ - DM3/M. G. Linde

At the time of the FTP meeting, site activation was complete at Hawaii and imminent at Guam. These sites are designated augmented emergency landing sites (AELS's). Six KSC personnel will be deployed to each site 5 days prior to each launch and will remain there until landing. The barrier will be installed the day prior to launch (the permanent parts are already in place). The MLS is calibrated 2 days prior to launch and is turned on for each landing opportunity. The Ball-Bars are permanently installed as are the PAPI's at Guam. The lighted aim point at Hawaii is on a boat that will be in place 2 days prior to launch. The xenon landing lights are put in position a day prior to launch. The only problem currently foreseen is that the barrier stanchions at Hawaii require an FAA waiver as they are very close to aircraft operational areas. Mr. Linde showed aerial views of both landing sites. The Hawaii runway is on a man-made peninsula off the mainland. Past the end of the Guam runway (past the barrier) is a 400 ft cliff to the ocean. Landing notification is expected 1 hour and 45 minutes prior to landing, but this may be reduced to only 45 minutes.

There was some discussion about the need to activate all the landing aids for all possible opportunities. The FTP will address requirements for general landing support at a later date.

7. □Carbon-Carbon Brake Program Status, DTO Plan□ - ES6/C. C. Campbell

This item was deferred until November.

8. □Low Pressure Tire Testing Requirements□ - ES6/C. C. Campbell

This item was deferred until November.

9. □63.5 Degree Inclination Range Safety Concerns□ - DM3/B. R. Hilty

This item was deferred until the September 22 meeting.

10. □Landing Sun Angle Window Testing□ - ES2/K. S. Edelstein

The current flight rule about sun angle is to guard against the sun shining directly into the pilot's eyes on final approach. Ms. Edelstein reviewed the material that has been found baked onto the orbiter forward windows and found that at sun incident angles over 40 degrees the windows can appear opaque. To perform testing to determine crew visibility constraints is outside the engineering directorates area of expertise and it was recommended that the FTP plan a series of tests with the Man-Systems Division at JSC.

11. □New Landing Gear Hydraulic Isolation Valve Control

a. VG3/S. V. Murry - A new isolation valve is being added that allows landing gear deployment without providing hydraulic pressure to the brakes, thus eliminating the uncommanded brake pressure problem that is potentially catastrophic. The new valves will be added to OV-105 in line, OV-102 for STS-53, OV-103 for STS-58, and to OV-104 for STS-63 (during the first "major mod" period for each vehicle). Software control must be provided in OI-21. The software will be compatible with either the new hardware or the old hardware since a mixed fleet of modified and unmodified orbiters will be flown for some time. The remaining issue then becomes how to reliably apply hydraulics to the brakes AFTER main gear touchdown. Currently brakes are available prior to main gear touchdown. The WOW signal is too unreliable in its current form to mode FCS or enable the brakes. A scheme has been devised to add the wheel speed sensors used in the antiskid system plus the existing WOW sensors in a voting scheme to determine WOW and thus enable brakes.

b. CB/A. M. Allen - The Astronaut Office position is very strong that the uncommanded brake pressure problem must be solved but not at the expense of brake capability. They recommend that the improved WOW system to enable brakes at main gear touchdown be provided. The FTP recommends the improved WOW/brake enable system be implemented concurrent with the new hydraulic isolation valve.

12. □SSME TVC On-Orbit Drift Concerns□ - EP2/J. M. Seriale-Grush

This item was deferred to a later meeting.

□Walk-On #2□: Vent Door Failure Analysis Results - RI-D/AC07/L. Wong

Since the return-to-flight, each flight has been analyzed to determine the effect of vent door failures. Mr. Wong presented the result of the first generic study on a single vent door group failed closed. The results are that for any single group failed closed (1 & 2, 3, 5, 6, 4 & 7, 8 & 9) are acceptable. In the 4 & 7 group, the a -2 percent margin of safety existed at the wing skin, upper rib caps, lower rib caps, and truss tubes. Rockwell and JSC orbiter both consider this acceptable. Positive margins over the factor of safety occur in all other areas.

Failures of the vent doors in the open position were not analyzed.

Mr. Wong expressed concern that multiple vent door failures could be catastrophic. The only recoverable case of vent door failures are those involving GPC failures where restringing would regain door function. Based on previous analysis and the hazards associated with dynamic restringing, the current flight rules do not allow restringing when only two midfuselage doors are failed closed; three must be failed before action is allowed.

□Action: 89/09/08-004□ - RI-D/AC07/L. Wong, RI-D/FB89/K. E. Lengner - Provide a coordinated Rockwell corporate position on any changes to the dynamic restringing flight rules (2-92C.3a and b) required to protect vehicle structure for insufficient venting.

The second meeting of the 60th A/E FTP took place September 22, 1989, at JSC in building 29, room 109 with Rockwell participating via teleconference.

□Walk-On #1□: Low Alpha Stretch Capability - RI-D/FB98/R. Johnson

Rockwell performed an analysis in support of the STS-34 Flight Readiness Review to determine if the angle-of-attack (alpha) modulation chosen for contingency aborts was acceptable. The scenario selected was an SSME out at earliest TAL capability (velocity of 7.5k ft/sec) with at second engine failure at a velocity of 12k ft/sec. Two trajectories were developed, first with an alpha of 40 degrees for the first pullout and 31 degrees on all subsequent pullouts, second with an alpha of 37 degrees on the first pullout and 31 degrees thereafter. For STS-34 with an orbital inclination of 34 degrees, the 40/31 alpha was acceptable while the 37/31 was unacceptable with wing leading edge temperatures exceeding 3400 degrees F for more than 30 seconds.

Rockwell also performed three cases in the continuing attempt to determine proper modulation for a due east (28.5 degree inclination) mission. The initial conditions for the cases are detailed in the enclosure, two cases were 37/31 alpha, the other case was a 37/34 alpha, and all were acceptable. Discussion followed on the validity of these cases to provide a baseline. All analysis to date indicates that these cases reflect near worst case. No placards are required for different MECO velocities based on present knowledge. Based on this preliminary study the A/E FTP determined that the flight rules should be changed to allow 37/31 alpha for due east missions.

□Action: 89/09/22-001□ - DM3/B. D. Perry - Provide a flight rule change to allow low alpha stretch of 37/31 degree alpha for due east (28.5 degree) missions.

NOTE: Following the FTP meeting, Rockwell discovered serious discrepancies with the initial 37 degree pullout on due east missions, therefore this action has been put on hold until the discrepancies have been resolved.

Mr. Joosten informed the panel that improved thermal models are being incorporated into the offline simulations to more exhaustively examine different trajectories.



□Action: 89/09/22-002□ - DM3/P. J. Bertsch - Provide the A/E FTP a schedule and plans for offline testing of low alpha stretch techniques.

1. □SSME Limits Management/Contingency Abort Safety Discussion□ (continued)

The ongoing discussion is to determine the proper course of action. Currently, SSME limits remain inhibited following the first engine failure until performance positively indicates that a safe crew situation can be accomplished following the next engine failure. The current risk versus risk indicators are that the catastrophic loss of the second engine is less risk than flying a contingency abort. With new flight software that decreases crew workload and improves structural margins, it is prudent to re-examine the limits management philosophy.

a. Contingency Abort Black Zone Region Definitions - DM36/J. V. Turner -

The studies were done on the shuttle engineering simulator (SES), flown manually by FCOD personnel utilizing the automated Nz hold guidance now available in OI-8C flight software. A run was considered successful if the Nz remained less than 3.5 g's, the qbar less than 800 psf, the bodyflap loads were less than the ultimate material limits, and there was no loss of control. The study showed that for two engines out there are no "black" (loss of crew and orbiter) regions except a small region around zero velocity on an RTLS (see enclosure). Significant three engine out black zones exist, most prominently from liftoff through SRB separation, and at velocities from about 8k ft/sec to 18k ft/sec. Most of these were due to the fact that an OMS dump was not considered to be possible and the cg was so far aft that the control surfaces were ineffective; if a dump could be accomplished it would decrease the black zones significantly. To prove that these studies are valid, additional structural investigation is required.

b. Contingency Structural/Airframe Margins - ES2/C. T. Modlin -

Mr. Modlin declined to appear at the FTP but stated to the chairman that the appropriate limits have been delivered to the contingency abort community. In subsequent meetings with the Flight Director's Office and briefings to senior NASA management, Mr. Modlin has provided the following information. The flight control limit of qbar = 800 psf will protect the structure under contingency situations. Rather than a flat 3.5 g Nz limit; the structural loads limit (primarily wing root bending moment) can be unconservatively taken to 90 percent of ultimate load which is equivalent to 126 percent of design load (based on 1.4 factor of safety). Mr. Modlin assessed aircraft experience in outside of limits cases and concluded that, in general, 90 percent of ultimate load represents a reasonable probability of structural survival -- but the vehicle will not be reusable.

c. Contingency Abort Training Records - DG66/W. A. Foster -

One of the significant issues in determining the acceptability of contingency aborts is the ability of the crew to perform the complex and time critical procedures. None of the training runs were targeted toward a known black zone, no runs with load errors were counted. Since OI-8C software with the auto Nz hold capability became available in the SMS a total of 49 runs have been made; of those 73 percent were successful. In the SES where more experienced crewmen are subject to less surprise by engine failures (engines are shutdown via crew pushbutton), 86 percent of the cases were executed successfully. Unsuccessful runs were generally caused by slow response in procedural execution, inadequate crew coordination resulting in missed procedural steps, or execution of the wrong procedure. This information only covers the first 3 months of training with the new software. Since these are training runs, it is expected that crew performance would improve with time. However, only a few of the runs were from skills lessons where the crew was not expecting a contingency abort. Mr. Foster will periodically report statistics from this

type of training to the A/E FTP.

d. SSME Redline Sensor Reliability Statistics - Rocketdyne-Canoga Park/AC11/R. E. Biggs - These statistics include all applicable flight type unit experience and sensor failure rate data applies only to the currently in-use types (e.g., -91 temp sensors). Normalizing to 1 million flights, the redline sensors would prevent catastrophe by shutting down a failing engine in 7700 cases; the redline sensors could not prevent a catastrophic engine failure in 5200 cases even if they were enabled, and would shutdown engines in 6966 cases that were instrumentation only failures or that would have continued to run without uncontained damage. Since the chances of properly or improperly shutting down engines is roughly equivalent, the proper course of action cannot be determined from these statistics.

2. Convair 990 Testing Program Overview, Goals, Timelines - MJ/R. D. Simpson

The orbiter has significant differences from conventional aircraft on its landing and rollout loads; existing simulation and analysis tools suffer from various problems, so the NSTS Program has decided to modify a Convair 990 aircraft to obtain experimental data on landing gear and tire performance. The aircraft is currently at DFRF undergoing modification. The first flights will take place in about a year; September 1990.

3. Heavyweight Landing Discussion: STS-32 nominal, STS-32 LDEF + SYNCOM Return, 256k RTLS

a. Airframe/Landing Gear Structural Margins - ES2/C. T. Modlin - The chairman summarized Mr. Modlin's concerns on STS-32. The return of LDEF and SYNCOM together exceed the certified landing weight by a considerably factor (241,000 lbs versus 230,000 lbs). Engineering has been performing an analysis to determine if reduced load factor in flight can allow a safe landing, and has determined that a simple extension of load factor reduction from weights above 230k lbs (see flight rule 8-19) is not acceptable. While there is long term work in process to determine if heavier return weights are acceptable, these results will not be available until significantly after STS-32. As a result the chairman has drafted a letter to the NSTS Program stating that operationally, LDEF retrieval will not be performed if SYNCOM cannot be deployed (DA8-89-264).

b. Tire/Brakes Margins - ES6/W. R. Acres - Deferred to the next A/E FTP.

c. Handling and Flying Differences - EH2/L. B. McWhorter - Deferred to the next A/E FTP.

d. Handling and Flying Procedural/Rules Changes - DF62/S. J. Elsner - There are no new procedures or rules under consideration. The landing speed should be 205 kts for weights above 220k lbs; the body bending filter is required for payload weights in excess of 10k lbs. The Nz limit for OV-102 has now been changed to be the same as the other orbiters; 1.85 g for weights above 230k lbs (contingency case). Runway selection is not a function of vehicle weight but a concrete runway is preferred for heavyweight orbiters with forward X cg considering slatdown rates. The crosswind limits are not a strong function of vehicle weights, but the A/E FTP directed that the 1990 Ames simulation consider the very heavy weights (currently no runs have been made above 240k, the TAL limit is 248k and the RTLS limit is 256k).

e. Braking, Nosewheel Steering, and Rollout Procedural/Rules Changes - DF43/M. J. Ferring - No procedures or rules changes are contemplated.

f. Special Flying/Landing Techniques - CB/F. L. Culbertson - The

piloting techniques are similar to standard but there is less margin for error an execution. In particular, the cg has a large impact, and stacking environmental factors gives even less margin. For example, the at 256k with braking started at 160 kts, the brakes absorb 240 million ft-lbs.

□Action: 89/09/22-003□ - ES6/W. R. Acres - Determine if acceptable landing weight envelope should include a tailwind placard to protect maximum brake energy.

#### 4. □STS-28 Results

a. RSOC/R16D/M. D. Marquette presented the results of the attempt to recreate the flight conditions on the 6 degree of freedom space vehicle dynamics simulator (SVDS) as the descent design group normally does post-flight. They used the monthly mean atmosphere modified with the observed density ( $q_{bar}$ ). Usually recreations are very close to flight observations but STS-28 was not as successful, possibly due to aero dispersions.

Numerous density shears were observed on this 57 degree ascending entry. The angle-of-attack ( $\alpha$ ) was reported by the crew to be saturated; the data shows that it was nearly saturated from Mach 8 to Mach 6 which was due to the TACAN update. The TACAN update at about Mach 8 can be clearly noted on many of the plots. The observation was made that  $\alpha$  is typically higher than the reference, STS-28 was slightly higher than normal. The aft RCS fuel usage was higher than normal but well within 1 sigma dispersions; the entry redline protects 3 sigma dispersions.

ED3/S. M. Derry showed that there is considerable evidence that there was an early and unsymmetrical transition in the boundary layer from laminar to turbulent flow. Based on post-flight visual inspection of tiles, gap fillers, and max temperature indicators on the structure; as well as telemetered bondline temperatures; it appears that the boundary layer on the port side of the bottom of the orbiter transitioned about 300 seconds earlier than usual in the entry profile. This would lead to some higher than normal -- although not hazardous -- torque on the vehicle. This type of torque is accounted for in aerodynamic analysis by the "bent airframe" term. The possible cause of the early transition was TPS work that was marginally acceptable. The greatest problem that results is additional TPS work that must be done in turnaround for the next flight.

EH22/M. M. Hammerschmidt presented the FCS evaluation of the STS-28 entry. In particular, there were rumors after the flight to the affect that the aileron trim was 2 degrees and the their was a force flight between the aileron and yaw jets. Mr. Hammerschmidt conclusively proved that these is no basis for these rumors.

Mr. Hammerschmidt also showed a higher than expected RCS usage that was well within systems dispersions, a steady state beta (sideslip) offset of about 0.4 degrees for  $q_{bar}$  greater than 40 psf that was unusual, and a "sine wave" response of aileron between the first and second roll reversal that was unique to this flight. The beta offset may be a data effect; the reduction of the SEADS data in another month may provide an answer to that question.

Mr. Hammerschmidt concluded that the FCS performed in a correct and expected manner to an external disturbance torque; the aileron and yaw jet activity was coordinated, the aileron trim was less than 0.5 degrees (3 degrees is the limit) and the yaw jets required for trim averaged less than 2 (of 4 available). The external disturbance that induced the unusual features of the flight may be related to transition of the boundary layer from laminar to turbulent flow. It is significant to note that the no yaw jet mode would

have been fully functional under these circumstances.

b. MPS Dump Impulse Concern - DM3/E. P. Gonzalez and DF6/M. R. Jenkins -

The ascent flight design system has been assuming an impulse from the MPS dump on the order of 8 ft/sec. It has been observed to be in the 12 to 13 fps range which leads to orbits on the order of 1.5 nmi higher than planned.

The only difference between the pre-accident dump and the current system is that the dump is performed with the engine bells in the stowed position -- which should have negligible effect.

After review of the data, the FTP decided that an increase of the MPS contribution from 8 to 11 fps was in order.

□Action: 89/09/22-004□ - DM36/E. P. Gonzalez - Initiate a CR to the flight design process to update the MPS dump velocity contribution on direct insertion flights to 11.0 fps.

5. □STS-30 Crosswind Landing: Plans for Future DTO's□ -- EH22/H. G. Law

This item was deferred to the next FTP meeting.

6. □Night Landing Requirements Revisit□ - DF6/P. E. Perkins

Mr. Perkins reviewed the GNC requirements which were extensively reviewed in the return-to-flight timeframe (see enclosure). Of primary interest is the statement -- made with the Astronaut Office concurrence at the time --- that the HUD is required for night landings.

CB/R. L. Gibson offered his personal observations from having performed a night landing on STS 41-D, that the HUD is very useful but not mandatory.

□

□Action: 89/09/22-005□ - CB/M. L. Coats - Provide consolidated Astronaut Office position as to HUD requirement for night landing. If it is required, a spare HUD should be manifested on all flights with a night landing without exception.

□Walk-On #2□: High Inclination Flight Range Safety Concerns - DM3/B. R. Hilty

This presentation was a status of the ongoing negotiations with the ESMC range safety officials for flights above 57 degrees inclination to 63.5 degrees. There are serious problems and disagreements over the safety of these flights with significant hurdles to be overcome. Mr. Hilty will continue to update the A/E FTP as required.

The third meeting, called number 60A, was held October 6, 1989 at JSC in building 29, room 109 with Rockwell participating via teleconference.

1. □RSOC OMS Tank Model Implementation□ - RSOC/R16D/A. E. Saybe

Flight design does not have a computer tool to determine the point during entry at which the OMS tanks will fail; thus abort propellant dump I-loads have not been rigorously defined. A tank model has been built into the 3 degree of freedom (DOF) descent design system (DDS) and will be included in the 6 DOF space vehicle dynamic simulator (SVDS). The tank model, largely copied from the shuttle engineering simulator model, is based upon a Rockwell study, STS-87-0045 with Amendment A, OMS tank propellant retention capability study. This study included slosh effects and was based on conservative assumptions. For example, in all cases where the RCS jets are firing, a 24 jet flowrate is used. Tank/screen breakdown should be delayed if fewer jets are fired. The tank breakdown also depends on acceleration angle which is roughly the angle from the normal that the tanks experience. At angles between 90 and 120 degrees the analysis is suspect enough for the information to be only included in the Volume 3 of the Shuttle Operational Data Book (SODB).

□Action: 89/10/06-001□ - RI-D/AD56/M. Ramos, EP4/K. R. Kroll - Ensure that all the data, curves, etc., required to document the OMS tank screen model are incorporated in the Shuttle Operational Data Book.

A test sequence of 100 cases will be run to validate the model. Clearly this is not an exhaustive test matrix, but all parties felt that this represented an adequate mix of cases to test all the extreme points.

The FTP believes that this model is not adequate for flight design purposes since it does not accurately reflect the different mixture ratios (and thus the tank quantities) for all the different configurations.

□Action: 89/10/06-002□ - RSOC/R16D/A. E. Saybe - Incorporate accurate mixture ratios into the OMS tank model.

The FTP recommends that the model also be incorporated into the Shuttle Avionics Integration Laboratory (SAIL) and the shuttle mission simulator (SMS).

□

2. □Contingency Abort OMS Dump Feasibility Study□ - RSOC/R16D/R. W. Hoffman

No OMS dump is performed in the 3 main engine out contingency cases RTLS "blue" (3 engines out from SRB sep to powered pitch around) or uphill contingency abort "green" (3 engines out from SRB sep to late TAL capability). A matrix of cases was run for these regimes a 30 second post-MECO dump start and worst case assumptions such as full OMS load (no previous dumps performed), heavy weight orbiter, hot (July) atmosphere. All cases were terminated at OMS screen breakdown (with the improved tank model) or at 20 percent which was considered to be the last comfortable time to continue an interconnected dump. In all cases significant propellant dumps were achieved and in all cases the 0.05 g level came prior to tank breakdown. Based on this study, the FTP decided to re-institute dumps in these regions with the cutoff to be the 0.05 g software cutoff.

□Action: 89/10/06-003□ - DF6/J. E. DeTroye - Write a crew procedures change request form 482 to incorporate an OMS contingency dump start in the RTLS CA Blue region and the CA Green region.

3. □Effect of C.G. on Contingency Abort Black Zones□ - DM3/P. J. Bertsch

This item was deferred to a later meeting.

4. □Late TAL Dump Timer□ - RSOC/R16D/R. W. Hoffman

A study was made to determine a standard late TAL OMS dump timer I-load. The assumptions included various OMS loads from 14k lbs to 25k lbs (full), hot (July) atmosphere, various inclinations from 28.5 to 63.5 degrees, aft cg, heavy weight orbiter, OMS engines off, RCS interconnected to 20 percent, and a 100 second post MECO dump start. The study showed that the 0.05 g Nz level in general came much earlier than 20 percent quantity remaining level or the model predicted screen breakdown time.

Since the late TAL window is so short, and significant improvement can be made in vehicle cg and downweight by maximizing the dump, and since the RCS is protected by the 0.05 g constraint, the FTP determined that the late TAL dump I-load should be based on a 20 percent quantity remaining in the tank. No further analysis needs to be performed on this scenario.

□Action: 89/10/06-004□ - RSOC/R16D/N. Guerra - Document the FTP decision into the flight design procedures that late TAL dump time should be based on 20 percent remaining in the OMS tanks.

The final meeting of the 60th A/E FTP was a splinter meeting on the topic of propellant ballasting and the impacts to press-to-ATO times. This meeting took place on October 10, 1989 at JSC in building 29 room 109 with no teleconference. The case of STS-31 was discussed. The press-to-ATO time is currently defined by using the delta velocity available based on: MPS with 2 sigma low performance to MECO; OMS loaded minus: trapped, flight performance reserve, dumped propellant, sequential OMS engine out attitude control, and cg ballast (usually zero); RCS loaded minus: trapped, gage error, usage from MECO to EI, sequential OMS engine out attitude control, 3 sigma entry usage from EI to Mach 1 and cg ballast (usually zero). For this case, the RCS cg

ballast is about 1600 lbs. If this were available to the press time it would avoid about 12 seconds of TAL exposure. Note that the cg ballast protects a 1 inch (3 sigma) variation in knowledge of the X cg location. The A/E FTP concluded that it was overly conservative to additively protect a 2 sigma low MPS day, a 3 sigma high RCS entry usage, and a 3 sigma variation in x cg. The A/E FTP believes that these were independent variables and therefore they could be root-sum-squared together - if they could be converted into equivalent terms (e.g., seconds of press time or pounds of propellant). If study indicates this is acceptable it will be presented to programmatic management for incorporation in the flight design groundrules and constraints.

□Action: 89/10/10-001□ - DM3/L. D. Davis - Initiate a study of the implications of RSS of 2 sigma MPS, 3 sigma RCS entry usage, and 3 sigma (1 inch) x cg ballast together to determine the x cg ballast requirements for the PTA determination.

Further, the A/E FTP recommended that the flight design community strive to keep any X cg ballast in the OMS since this precludes OMS engine sequential shutdown and thereby allows use of an additional 124 lbs OMS propellant and 70 lbs RCS propellant for the press call.

The October A/E FTP meeting has been canceled due to conflict with the STS-34 mission. The next A/E FTP meeting is planned to take place on November 17 at JSC building 29, room 109.

Original Signed By:  
N. Wayne Hale, Jr.

Enclosure