National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas
77058

NASA

Reply to Attn of: CB-89-180

SEP 07 1989

TO: CA/Director, Flight Crew Operations
THRU: CB/Chief, Astronaut Office

FROM: CB/Commander, STS-27

SUBJECT: STS-27 Flight Crew Report

The STS-27 flight crew report is herewith forwarded.

Robert L. Gibson

Enclosure

cc:
See list

CB/RLGibson:lb:6/28/89:32796

STS-27 FLIGHT CREW REPORT

Robert L. Gibson
Commander

Guy S. Gardner
Pilot

Jerry L. Ross
Mission Specialist

Richard M. Mullane
Mission Specialist

William M. Shepherd
Mission Specialist

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I. INTRODUCTION

STS-27 was launched from Pad 39B at the Kennedy Space Center, Florida on December 2, 1988, at 9:30 a.m. EST. The launch period commenced at 6:40 a.m. EST. The launch occurred well into the launch period due to delays caused by unsuitable winds at higher altitudes. A launch attempt had been canceled the previous day for unsatisfactory high altitude winds after approximately two and one half hours of hold time by the crew in the vehicle. The launch was the third flight of the Space Shuttle Orbiter Atlantis, and was a direct insertion profile to a 240 NM apogee with an OMS-2 burn to a circular orbit. The vehicle achieved an orbit inclination of 57 degrees. The flight concluded with a landing on the Edwards AFB lake bed runway 17 on December 6, 1988, at 3:36 p.m. PST. The mission duration was four days, nine hours, and six minutes (105.1 hours) with 68 orbits. The five member crew consisted of Cdr. Robert L. Gibson, USN (Commander); Col. Guy. S. Gardner, USAF (Pilot); Col. Richard M. Mullane, USAF (Mission Specialist 1); Lt. Col. Jerry L. Ross, USAF (Mission Specialist 2); and Cdr. William M. Shepherd, USN (Mission Specialist 3).

The primary cargo aboard the flight was a classified DOD payload. The RMS was carried, as were several classified secondary payloads which were declassified subsequent to the mission. Some of these included the APE, CRUX, tests using the AMOS, and the VFT. Medical DSO performed by the crew were DSO 450 (Salivary Cortisol Level), DSO 458 (Salivary Acetaminophen Levels), DSO 466 (Cardiovascular Assessment), and DSO 467 (Baroreflex Function). The crew conducted extensive Earth observation with handheld photography utilizing the 35 mm Nikons, 70 mm Hasselblad cameras, as well as the larger format Aero-Linhoff camera because of the unique opportunity for Earth observation afforded by this 57 degree inclination orbit.

Classified aspects of this mission are discussed in a classified supplement covering the primary payload portion of the mission. This report deals with the major crew observations, recommendations, and significant Orbiter systems problems encountered during STS-27 training and flight.

II. PREFLIGHT

GENERAL

The crew of STS-27 was initially assigned in September 1986 as one of two crews supporting a simulated Shuttle mission designated STS 81-A(T). This was to be an exercise designed to provide Rockwell Shuttle Operations Company with an opportunity to develop the flight design, software products, and simulator loads needed to support a Shuttle mission as a capability enhancement while the STS program was rebuilding after STS 51-L. Mission 81-A(T) was a secret flight and was in actuality a simulation of STS-27, as somewhat of a "pre-cycle 1" product. The crew commenced active training in early October 1986 on STS 81-A(T) at a training rate designed not to exceed 20 hours per week in training time. The initial STS 81-A(T) training load was delivered in late May 1987 and was available from that point to support STS-27 training. This was a major benefit to the training flow, as this was far earlier than a flight specific load would generally be available to a crew. The entire process of STS 81-A(T), which included a CIR and a FOR, made all of these same reviews that much further advanced and mature when STS-27 was developed. The crew was formally assigned to STS-27 on September 15, 1987, and training from that point shifted in emphasis from 81-A(T) to STS-27.

The classified nature of STS 81-A(T) and STS-27 made many of the routine aspects of a Shuttle mission more difficult and time consuming to accomplish. Most issues related to the flight could not be discussed over the telephone, for example: launch window, trajectory, inclination, payload activities, etc.; and required face-to-face meetings to resolve. All training in Building 9 or the WETF was classified secret and required that those facilities be secured for the entire day that training occurred. As a result, all EVA, RMS, crew escape, CAP timeline, CCTV, or training in any of the mock-ups was classified secret as part of the overall "umbrella" policy. There were also no scheduled
STS-27 press opportunities when the crew was named, nor was there an L-30 press conference in the original plan. This was modified after the launch of STS-26 due to the heavy media interest in Shuttle launches to permit a press day for the STS-27 crew to conduct individual interviews for "human interest" and hometown articles. This proved, in actuality, to be a very difficult situation to put the crew members in since the media was determined to find out all they could about the mission, and their questions were carefully constructed to provide an opportunity for the crew members to inadvertently reveal classified facts during the interviews. As a result, the STS-27 crew felt that it was not advisable to conduct a press conference or convene a press day for DOD missions.

RECOMMENDATION: Do not conduct press conferences in any form for DOD crews.

A. TRAINING

GENERIC: The crew had a luxury, not available to most training flows, of having had nearly two years to train for STS-27 because of STS 81-A(T), with a simulator training load available for over one and one half years. As a result, the crew and the mission control teams were very well trained to perform the mission. As part of the training, the STS-27 crew trained on at least the core syllabus for IUS, PAM, RMS, and rendezvous in accordance with DOD desires and the overall umbrella security policy. This may have added some unnecessary training to the crew work load, but it was felt to be justified in the overall DOD requirements for training security.

SHUTTLE MISSION SIMULATOR (SMS): The crew spent nearly 600 hours in the SMS for STS-27 training in standalone and integrated simulations. (This does not include STS 81-A(T) or proficiency sessions.) The crew felt that the SMS provided excellent mission training and that the SMS support they received was excellent. STS-26 and STS-27 were the last two missions to utilize the "old host" computer for the training loads, and, therefore, logistic support was declining for the old host as STS-27 progressed. In spite of less than ideal reliability from the old host, the efforts of the maintenance and operations personnel, and the intense management attention provided by the Operations Integration Team overcame all the problems with this final use of the old host and resulted in the accomplishment of all STS-27 training objectives. These problems had become relatively frequent by the end of STS-27 training, and the successful accomplishment of the required training could not have happened without the intense scrutiny and effort provided. The crew was very grateful of the excellent and capable support they received.

One aspect of the SMS which was independent of the old host and continues to be a major limitation to the fidelity of the training is the poor quality and reliability of the Aft Crew Station visual scenes, the aft and overhead windows. During simulations which utilized these views, it was necessary to recycle the DIG at least once per hour due to freezing of the displays or lack of control over the Orbiter CCTV system. In addition, the poor quality of the images in these windows made them very marginal and resulted in negative training for certain crew tasks. During RMS and rendezvous core training for example, the poor quality and occasional complete unusability of the visuals caused the crew to develop alternate methods (other than visual) to derive data, such as RMS digital displays, radar data, etc. Understanding that the aft visual system is scheduled for upgrade in the next several years, the crew can only note that future crews will have to contend with this same poor quality in their training, and urge that all possible priority be placed on expediting this upgrade. In the interim, all efforts to maximize the clarity and carefully maintain these visuals should be provided.

RECOMMENDATION: Maintain the SMS aft visual system to maximize the clarity and utility of the scenes. Expedite the upgrade and replacement of the aft visual system.

The SMS provided excellent systems training during the RMS core courses, and it was possible to achieve very accurate and complete operations and malfunction training. RMS dynamics in the SMS are extremely lacking, however, and other facilities such as the SES or RMS facilities at SIMFAC should be utilized to provide RMS dynamics training.

RECOMMENDATION: Continue the use of the SES and SIMFAC facilities to provide RMS dynamic training in the RMS core syllabus.

WETF: Training in the WETF included EVA as well as crew escape and water survival training. Due to the classified nature of the flight, no payload mock-up was available for EVA training. Decisions regarding EVA were based on the cargo drawings in the cargo systems manual. This caused some erroneous decisions to be made due to the relatively limited fidelity of these drawings. It was not until very late in the flight preparation flow that these decisions were shown to be incorrect with insufficient time left to change EVA procedures. Accordingly, decisions related to EVA must be based on close observation of actual flight hardware, particularly in cases where no WETF mock-ups are available.

RECOMMENDATION: Maximize the accuracy of the drawings in the cargo systems manual (within security limitation), and ensure that EVA related issues are decided based on flight hardware.

KSC TRAINING: All training evolutions conducted at KSC were very professionally carried out. It was the opinion of the crew that all the necessary training was accomplished with no excess material presented, thanks in great part to the efforts of the VITT to streamline the training. Night training in the M113 APC was excellent and should be continued since virtually all crews have a portion of their countdowns conducted in darkness.

RECOMMENDATION: Continue night suited training in the M 113 armored personnel carrier.

The crew participated in IVT, CEIT, as well as TCDT, and launch. In all of these very major tests, the assistance and support of the VITT was excellent and was instrumental in the smooth accomplishment of the tests.

B. INTEGRATED SIMULATIONS

The STS-27 crew benefited from its participation in the 81-AT integrated simulations, and took part in one ascent, one entry, and nine orbit integrated 81-AT simulations. Five of the orbit simulations were joint integrated simulations.

The STS-27 training included the following integrated simulations: four ascent, three entry, one systems, one deorbit prep, four orbit, and one 36-hour long simulation. The orbit simulations and the long simulation were the joint integrated simulations. This crew supports the inclusion of a long simulation in the training syllabus when the mission dictates and resources permit. The simulations were well scripted and provided invaluable training for both the ground controllers and the flight crew.

RECOMMENDATION: Include a long simulation on missions which are significantly different or complicated over prior flights.

C. TCDT

All crew members felt that the entire TCDT activity was most beneficial and that it was well prepared. The emergency training, both classroom and at the pad, was purposeful, succinct, and professionally conducted. It was felt that the LES suited training in the STA's and the M113 APC driving was important and should be continued.

The actual dry count identified two problems that were corrected for launch. JSC MCC to KSC Launch Control Center coordination was not very smooth during the dry count and the air to ground communication had very bad echoes (or delays) that caused it to be totally unsatisfactory. The communication quality was so poor that it would not have permitted launch had the same problem occurred on launch day.

RECOMMENDATION: Continue to perform a TCDT for every launch.

With the new equipment associated with crew escape, and the addition of more flight deck cue cards, the management of the mission specialist's FDF material requires additional attention. Therefore, the entire FDF complement should be present at TCDT to permit the crew to finalize its desired placement and tethering. The decreased mobility of the LES dictates that the stowage location of the spare HIU and adapter cable be carefully selected. Each crew should consider this during TCDT, using representative hardware and containers.

RECOMMENDATION: Include all ascent FDF stowage items for TCDT.

The mode one emergency egress was performed in a controlled manner to preclude damage to flight hardware and the Orbiter. The crew's experience was that it was easier to egress if the breakaway LES quick disconnects were manually disconnected to eliminate hangups. The crew also felt that the emergency egress should be carried through the slidewire basket entry.

The movement of the crew dinner with management from the actual launch timeframe to the TCDT L-1 day is a good idea, and should be continued. KSC provided excellent control of the press coverage for the DOD mission throughout the TCDT exercise.

D. ISOLATION

The crew entered crew quarters Thanksgiving night for a scheduled December 1, 1989, launch date. This provided adequate time for shifting the crew's sleep cycle. The JSC crew quarters facilities were very good. Problems were encountered with the air conditioning and the video systems. The air conditioner problems were corrected, but the VTR and satellite video systems as installed were not operating correctly.

RECOMMENDATION: Fix the video tape recorder and the satellite dish systems in the JSC crew quarters.

The crew quarters facilities at KSC were also very good, but several crew members were awakened by discussions in the lounge areas during crew sleep periods. The soundproofing between individual areas is not that extensive, so care must be exercised to avoid discussions and TV and music levels that could wake up the crew.

RECOMMENDATION: Do not use the hallways or lounge areas in the KSC crew quarters for conferences during crew sleep periods. Utilize the conference room or office space.

The Astronaut Family Support Plan was excellent and provided an immeasurably great assistance to the crew members. Three of the crew members had flown flights prior to the Plan's implementation, and the improvement in the crew's "peace of mind" and ability to focus on the mission without worrying about the logistics of family support is a wonderful enhancement over prior years.

RECOMMENDATION: Continue the Family Support Plan on all future missions.

III. LAUNCH OPERATIONS

A. INGRESS

Atlantis launched on the second attempt on December 2, 1988, after a scrub on December 1, due to load exceedances caused by winds at altitude. Due to the "Lessons Learned" during TCDT, ingress and crew strap-in were conducted within the time allotted on both days. During ingress, the crew is required to crawl on hands and knees through the hatch tunnel and across panel MA73. Objects such as pens or pencils in the lower leg pockets of the suits are subject to being pulled out in this process. Accordingly, it is recommended that these pockets not be utilized or that a velcro flap be included to close off these pockets.

RECOMMENDATION: To preclude losing pens and pencils during orbit ingress, do not store pens or pencils in the leg pockets of the suit. Add a velcro flap to these pockets if they must be used.

Four of the five crew members ingressed with gloves off, which made it easier to maneuver into the seats and assist with strap in. MS-3, the middeck crewman, noted that it was difficult to avoid stepping on portions of the airlock wall. Since this and other areas of the middeck are "no step" areas, they should be suitably marked.

RECOMMENDATION: Mark "no step" areas of the Orbiter cabin for ingress.

Once established in the seat, MS-3 noted that he had a very difficult time repositioning himself during strap in and during countdown due to the lack of handholds. The addition of some sort of handhold, perhaps mounted to the lockers, would greatly facilitate ingress and comfort for the middeck crew member.

RECOMMENDATION: Provide handholds for the middeck seated crewman to assist in seat ingress and improve mobility.

The ASP reported during TCDT and launch that the DOD metal window covers on W8 and W9 facilitated strap in by providing more locations to safely stand without worry of stepping on the windows.

B. TERMINAL COUNT

The crew spent over four and a half hours in the Orbiter on December 1 in the countdown hold at T-9 minutes while attempting at attain favorable winds aloft. Due partly to the relatively cool temperatures, the crew was relatively comfortable in the suits over this time period and did not perform any pressurization of the suits. The crew was on board the following day for over four hours before launch, and only one crewman (the one with the tightest suit) pressurized his suit one time during the countdown. During the countdown, there was a discussion by the LCC of having MS-3 cycle a switch or circuit breaker on panel ML 31C. Since MS-3 could not reach all of this panel while strapped in, it is advisable to stow a "swizzle stick" on the middeck for MS-3 to utilize.

RECOMMENDATION: Provide a middeck "swizzle stick" for MS-3 to aid in prelaunch troubleshooting.

Due to changing weather at the TAL sites, it was necessary to change TACAN and MLS channels several times during the two launch attempts. The channel switches were very difficult to reach and it was best to have MS-2 activate the switches rather than the commander or pilot. None of the crew members could read the channel numbers, however, until the pilot utilized his hand hold mirror to read them on the first countdown attempt. For the actual launch day, the pilot added an EVA wrist mirror on his left arm to aid in reading the channel windows.

RECOMMENDATION: The Orbiter commander or pilot should wear an EVA wrist mirror to assist in reading TACAN or MLS channels prelaunch.

The crew of STS-27 left their gloves off for terminal countdown and did not put them on until the countdown had progressed inside T-9 minutes. At that time, calls were made on the intercom to check gloves, communications volumes, and suit zippers (if opened to improve cooling airflow).

The count was held at T-9 minutes on the launch day for nearly two hours waiting for favorable winds at altitude. Nearing the end of the launch period, favorable wind conditions occurred and the clock was resumed from T-9 minutes. APU start was normal at T-5 minutes with a barberpoled talkback on APU 2 due to incorrect temperature readings on its steam vent. At approximately three minutes, a weather hold was called for a ceiling which had just violated the launch requirements at Zaragoza, Spain, the primary Trans-Atlantic Landing (TAL) site. The clock was therefore continued to T-31 seconds where the countdown was stopped. Thanks to a pilot report from an astronaut airborne at Zaragoza who reported the weather improving, the mission management team made the decision to waiver the ceiling requirements by 1,000 feet and to proceed with launch.

RECOMMENDATION: Continue to support launches with weather observers airborne at the TAL sites.

C. LAUNCH

Once the decision had been made to commit to launch, the countdown clock was very expeditiously restarted from 31 seconds. Main Engine start was normal, and SRB ignition and liftoff occurred at 9:30:34 EST. It was the opinion of the three crew members with prior flights, that the levels of noise and vibration in first stage felt slightly reduced due to the parachutes, pressure suits, and equipment worn, compared to the LEH's and flight suits on pre 51-L flights. The roll maneuver was of approximately 140 degrees and a two stage throttle down was noted with a intermediate stop at 96 percemt chamber pressure. Load relief was relatively active in the lateral direction and a roll error needle deflection of over four degrees was seen. Maximum dynamic pressure occurred at an MET of 01:07 at an indicated airspeed of 464 KEAS. SRB tailoff and separation were normal with the usual "dusting" of the windshields occurring due to the SRB separation. No problems were encountered with high PPO2 on STS-27 due to the limited number of suit pressurizations performed and the brief amount of time that the crew had their visors closed.

Very shortly after SRB separation, the crew noticed a low level vibration similar to a very mild "pogo" which continued throughout second stage all the way to MECO. This buffet or vibration was very uncharacteristic of previous flights that the three flight-experienced crew members had seen. Postflight data analysis has shown that there was a vibration present which manifested itself in a 3Hz oscillation in pitch rate of roughly .25 degree/sec peak to peak. The resulting vibration was of the order of .035g at 3 Hz and was attributed to the payload and mounting interaction. (See Appendix Figures 1 & 2). All of the crew members noted a tendency to ride up in their seats as the acceleration level increased, and it was felt that an additional strap to hold the seat belt down ("crotch strap") would be effective at reducing this effect.

RECOMMENDATION: Include an additional seat belt strap to restrain the lap belt and crew member down in the seat.

The crew noticed the usual amount of white streaking on the windshield due to the butcher paper over the RCS jets. Longitudinal acceleration peaked at three g's and throttling began at 07:27 MET. The commander's and pilot's overhead flight books remained at the correct place due to the increased velcro on the pages. MECO occurred at 08:34 MET and was on-speed. The profile flown was direct insertion with no OMS-1 burn. The portable tape recorder was used to record all on-board communications since DOD flights do not record ICOM on the OPS recorders. This procedure should be utilized by all crews because it greatly facilitates debriefing and postflight data analysis to have the recording immediately available.

RECOMMENDATION: Continue to utilize the portable tape recorder to record on-board ICOM and Air to Ground for launch.

D. POST INSERTION

Postinsertion progressed normally after the completion of OMS-2 which began at 42:35 MET and burned for 3:34. The major changes in postinsertion involved the handling of the LES suits, and MS-3 had organized the middeck to facilitate the handling of the suits. The LES suits were taken off sequentially after OMS-2. Each suit was stowed in a large net bag along with flight boots. These bags were tied to the middeck floor near AV Bay 3. Kneeboards, gloves, comm caps, and helmets were stowed in helmet bags. These bags were too small, however, to fit the new helmet.

RECOMMENDATION: Increase the size of the helmet bags to fit the LES helmets.

The helmet bags were stowed on the starboard side forward behind the mesh net. Three "Return to Houston" bags were tied to the deck forward of AV Bay 3. One was used for stowage of the thermal underwear, one was for FDF material, and the third became the container for all film and video tapes. Harnesses and parachute containers were stowed temporarily under the sleeping bags. As they were taken off, each was taped up to preclude actuation of the various handles. MS seats were folded down without parachute containers inside. All three were stowed under the lockers forward of AV Bay 3. The suit fans and FDF bags were stowed with the helmet bags. Oxygen hoses and electrical wiring were secured with gray tape and left in place. Once the airlock inner hatch was open, the suit bags, harnesses, parachute containers, and "Return to Houston" bags were placed inside. The suits were not taken out of the net bags until entry day.

IV. ORBIT OPERATIONS

A. CLASSIFIED OPERATIONS

Orbiter operations of a classified nature are discussed in a secret supplement to this report.

B. SECONDARY PAYLOADS

The following secondary payloads were assigned to STS-27: OASIS II; AMOS; APE; Clouds; CRUX; RME III; and VFT II. Lighting conditions during the flight prevented the operation of APE and AMOS. Other secondary payloads were successfully operated with the exception of the clouds camera which failed during the mission. The APE camera was then used to complete the photographic requirements. Postflight analysis showed that the clouds camera had a blown fuse. The RME had the message "SYS BATT LOW" displayed at each of the scheduled data module replacement times. The VFT operations were scheduled for 15 minutes per crewman. Actual time required to perform the tests was closer to 30 minutes, and it was much easier to perform the tests with a second crew member recording the data. The operation of the VFT on orbit called for a battery change out mid-mission. The battery replacement had never been trained premission, and resulted in considerable time being wasted in orbit.

RECOMMENDATION: Include all planned secondary payload operations in crew training requirements.

C. ORBITER TILE SURVEY

On flight day three, a survey of the Orbiter's TPS was performed using the RMS end effector camera. RMS power up and check out were nominal except for the fact that the wrist roll joint displayed +0.4 degree with the arm still cradled (nominal is 0.0 + or -0.2 degree). MCC was informed and the crew was told to continue.

At the first use of the brake switch, the operator thought that the switch had been installed upside down since it lever-locked only in the OFF position. When the switch was in the ON position, it could be easily bumped to OFF and a pencil was inserted through the switch guards to prevent such movement. In postflight discussions, it was found that the operator's confusion was caused by the fact that the switch in the SMS has significantly more friction and gives the "feeling" that it also locks in the ON position. It should be noted that this is not the first time that an RMS operator has been confused by the brake switch design. On at least one other mission, the crew asked if the switch had been installed upside down. In the long term, the basic switch design should be modified.

RECOMMENDATION: All RMS operators should be made aware of the differences in the flight and simulator brake switch feel. The switch should be lockable in both the ON and OFF positions.

All published exterior tile surveys, except survey E, were requested by MCC. They also teleprinted aboard survey procedures for the OMS pods and tail surfaces. Generally, the surveys went well. In many cases the video resolution was good enough to read the tile nomenclature. Major Orbiter features such as the gear doors, ET doors, ET forward attach point, star tracker doors, etc., were easily distinguished and provided excellent landmarks for orientation. Tile damage was also easily observed but the exact depth of the damage was difficult to estimate. As was to be expected, the port side and port belly of the Orbiter were easier to view than the starboard side. Damage to the starboard belly could be seen, but only at extreme oblique angles.

The quality of the scenes was heavily dependent upon lighting conditions and the crew was allowed to manually maneuver the Orbiter to optimize those conditions. The CCTV views in the Reference Data Section of the PDRS Checklist are of marginal assistance.

RECOMMENDATION: Provide a synoptic view of the Orbiter with the areas being surveyed highlighted in some manner, e.g., with shading for use during RMS tile surveys.

Surveys B, C, and D involved movement of the wrist yaw joint without a direct view of that joint, so the operator is totally dependent upon ground verification of the procedure for collision avoidance. Because some modification of the joint angles is required at each of these locations to provide sufficient viewing, it would greatly enhance the operational flexibility of the procedure to provide the approximate Orbiter clearances at each of the survey positions.

RECOMMENDATION: For any of the RMS surveys where a joint is being moved without direct or indirect crew visibility, provide the approximate clearance between the moving part of the arm and Orbiter.

In some cases, the operator found it desirable to move the wrist yaw joint to angles that exceeded those given in the published survey. In particular, through the use of the wrist yaw and roll joints, greater areas of tile could be observed in surveys B, C, and D.

RECOMMENDATION: Modify the RMS tile survey procedures so that they list the maximum allowable ranges of wrist joints at a given location.

Procedure E was not performed. Consideration was given to stowing the MPM's and performing a modified E survey that would have given better visibility of the suspected damage area. For various operational constraints this was not done, but in retrospect it probably would have provided the best view of the damage. In any event, the procedure would have had to have been teleprinted on board.

RECOMMENDATION: Add the stowed MPM survey procedure to the PDRS checklist.

MCC also requested surveys of the OMS pods and tail surfaces, but these were not part of the published checklist and had to be teleprinted on board. They were executed with no difficulty.

RECOMMENDATION: Add the OMS pod and tail surface surveys to the PDRS checklist.

From the on-board CCTV views, it was the crew's opinion that the tile damage on the underside of the Orbiter's starboard side was more extensive than any previously encountered. The number of damaged areas, several of which extended over multiple tiles, could be clearly seen to be extensive, and was concentrated from the chine area reaching back to the main landing gear door. Since there were large areas of the chine which could not be seen, the crew was of the opinion that the survey from the starboard side (Position E) should be performed to more fully understand the total damage. A video tape of the tile surveys was downlinked using the STVS to allow an evaluation of the damage. Unfortunately, the STVS mode available broke up the video tape into "snapshots" every three seconds.

The resulting poor quality and resolution of the downlinked video caused the evaluations of the data to conclude that there was no significant damage and that it was only surface tile coloration showing up in the video, despite the crew's verbal descriptions to the MCC which were based on much better video. As a result, the MCC recommendation to the crew was that the additional survey was not required and the crew, believing that the "real experts" were on the ground, deferred to MCC's recommendation. It was only postlanding that the full extent of the tile damage, including a missing tile on the starboard chine, was realized. Where Orbiter damage is being assessed, particularly involving subtle details such as tile damage, the STVS should not be used to downlink information for analysis.

RECOMMENDATION: Do not utilize secure television to downlink video data for damage analysis when resolution is critical. Ensure that crew comments are included in damage assessments.

D. ORBITER PERFORMANCE

The overall functioning of OV-104 "Atlantis" was excellent on STS-27 with mainly minor discrepancies in subsystems. The one significant malfunction was in humidity separator B which was handled expeditiously by the pilot and MS-3 and was therefore not an impact to the mission timeline. Comments and malfunctions in some of the Orbiter subsystems are discussed in this section.

1. RCS/OMS

After switching to the RCS "B" helium regulators on flight day three, the right RCS oxidizer tank pressure decreased gradually from 249 to 242 psi on vernier jets. Following an RCS burn, the tank pressure dropped to 236 psi and slowly recovered to 240 psi. The right RCS was then reconfigured back to the "A" regulator and a crossfeed from the right initiated to deplete the right RCS to maximize blowdown capability. Straight feed was selected for reentry.

2. ECLSS

a. Humidity Separator B. On the morning of day two, loose water was discovered on the middeck floor. After examining the subfloor area by looking through the deck access doors, it was determined that humidity separator B was blowing droplets of water onto the LIOH stowage container. Approximately two gallons of water had accumulated on the forward side of this box, with some smaller globs of water on the underside of the LIOH box and on the surface of the crew module pressure skin. The free-water IFM was conducted and the water was vented to vacuum. The A humidity separator was turned on and worked normally. It was noted by the crew while attempting to vacuum the free water, that not all locations could be vacuumed with the 90 degree squared off tip of the hose. An additional angled tip (probably 30-40 degrees) would greatly facilitate in reaching water in some locations.

RECOMMENDATION: Include an additional vacuum hose attachment with a 30-40 degree angled tip for free water disposal.

The power screwdriver was a great aid in removing panels and getting under the middeck but it needed more torque.

RECOMMENDATION: Fly a more powerful power screwdriver.

Hooking up the water disposal hose required isolating the waste water tank. This procedure could have been performed more smoothly if the contingency water cross-ties appeared on the schematic on the ML 26 panel. This is a generic problem for a number of Orbiter systems; there is no agreement between schematics on individual panels, SSSH drawings, pocket checklists, malfunction procedures, or the IFM manual. This may impact critical contingency procedures.

RECOMMENDATION: Investigate the feasibility of standardizing schematics on Orbiter panels, SSSH Drawing, pocket checklists and malfunction procedures, and the IFM manual.

For extended duration missions, IFM will be a major factor in maintaining the operability and habitability of the Orbiter. IFM is presently used to bypass failed components and replace at the LRU level.

RECOMMENDATION: Examine modifications to the humidity separators, cabin fans, IMU fans, water pumps, and other ECLSS components which will allow for limited on-orbit servicing and repair.

b. Cabin Fans. The cabin fans and LIOH canisters worked nominally. There was still a small amount of LIOH dust which was left in the cabin after these canisters were handled.

c. Cabin Temperature Controllers. During the procedure to switch to the alternate cabin temperature controller, the linkage was pinned to the #2 controller. After several minutes of observation, the controller had not moved from the position with the control arm fully forward. The cockpit dial was repositioned and the controller was observed for several more minutes with no motion apparent. The original controller was reconnected to the linkage and left in operation for the duration of the flight. For entry day, the cabin temperature was lowered as much as possible to make the LES suits more comfortable. Once in the suit, however, even moderate activity generated a lot of heating. Any way that the crew can drive the cabin temperature down a few degrees will have a large impact on the comfort level in the suit for reentry.

RECOMMENDATION: Crews should reduce cabin temperature markedly during deorbit prep to enhance comfort in the suits.

d. Cabin Filters/Air Quality. Air quality was good. There were very minor amounts of debris in the cabin air and on the cabin filters. On day two, the filter cleaning procedures for the flight deck and middeck were performed. This took one person approximately one hour. The access to filter areas was very good. The use of the small hose for the vacuum cleaner would have made this task go faster. The WCS filter screen was cleaned twice during the mission. In both cases, the debris on the screen was moderate.

e. Water Quality. There was a moderate amount of iodine in the potable water, detectable by a brownish tint and slight iodine odor. These were not objectionable, but were quite noticeable.

f. WCS. The WCS functioning was excellent during the flight. Stowage and utility of WCS-related items was excellent.

3. APU/Hydraulic

During Countdown, the APU 2 steam vent temperature indication dropped below 130°F due to high GSE load requirements and a voltage drop at the sensor. The steam vent heaters were confirmed to be cycling properly, so a normal start (with a barberpoled talkback) was performed on APU 2. The temperature reading recovered to normal range during ascent. On orbit, the crew noted that hydraulic pressures generated by circulation pump operation are much lower than those displayed in the SMS. Several anomalies occurred in the GG Bed heaters on APU 2, beginning with activation of the GG Bed "A" heaters. This heater failed to operate at all, so the "B" heater was turned on. This appeared to fail on, as the temperature rose to 480°F before it dropped to 352°F. It subsequently cycled from 352°F to 428°F normally. At EI-13 when APU 2 was started prior to entry, its accumulator pressure stayed at 2450 PSI with a circulation pump pressure indication of 42 psi. After several minutes, the accumulator pressure rose to 3,100 psi, or normal system operating pressure, indicating a possible sticking priority valve was responsible for the reduced pressure.

4. GNC

A + X COAS alignment was performed while the Orbiter was in daylight (due to high Beta angle), looking over a dark Earth, away from the Sun. Although it was normally easy to see stars over a dark Earth away from the Sun, the attitude chosen resulted in the Sun shining on the forward window (W3). The sun glare on the residue on the window made it extremely difficult to see through W3. Future COAS alignment attitudes should ensure the Sun is not shining on the window. A normal -Z COAS alignment was accomplished during an Orbiter night pass early on Day 2.

The -Y star tracker failed self-test twice, but operated normally. This was a known problem with star tracker serial number 8, due to a position problem with the self-test artificial star. GNC will implement procedures to ensure that future crews are briefed to expect this behavior with SN 8.

5. Communications

The actions taken by MCC between TCDT and the launch date adequately fixed the very bad echo on air to ground that was experienced at TCDT. These actions, as well as the added communication checks from MCC to each crewman as they were strapped in, gave the crew confidence in the communication systems.

RECOMMENDATION: Continue the communication checks from MCC to each crew member as they complete strap in.

On the launch scrub day during preparation for exiting the crew compartment, MS-2 experienced what felt like an electrical shock in his headset ear cup and in his fingers when he grasped the clip on the back of his HIU. This was similar to an experience that he had reported during training and was caused by an internal short in the earphone transducer.

On orbit, the speaker and hand held microphones were used both on the flight deck and middeck. As briefed by our training team, only A/G 1 was placed on T/R. A/G 2, ICOM 1, and ICOM 2, were all off, and A/A was in rec. This eliminated the volume difference noted by the crew of STS-26 between the transmitted and received audio over the two speakers.

The availability of two TDRS satellites was a new and welcomed capability. This provided timely communication on orbit and essentially continuous communications during reentry. The MCC used very good discipline in the judicious use of the nearly continuous communications capability.

The STVS DTO was completed satisfactorily. The STVS was also used to downlink the tile survey video. Postflight discussions have revealed that the fidelity of the images received through the STVS were not sufficient to permit an accurate evaluation on the ground of the extent of the tile damage observed on board.

RECOMMENDATION: Do not rely on STVS video to perform damage assessments.

6. TAGS

When TAGS was first powered on, it indicated that it had a jam. This problem was cleared using the cue card procedures. Subsequent test messages yielded very good quality reproduction. TAGS jammed during the first sleep period. Approximately 25 exposed pages were in the tray and one was stuck in the exit rollers from the developer. The jam clearing tool was used to remove all of the visible paper from the rollers; however, that did not fix the problem and TAGS was subsequently powered off for the rest of the mission. The paper was sticky and had a curl in it when it came out of the TAGS. The paper tended to double up in the tray and eventually this appeared to cause the paper to jam in the machine. The jam clearing tool had a narrow set of jaws with fairly sharp teeth on them. They tended to cut/tear the paper when extracting it from the TAGS rollers. This tool needs a broader gripping surface and less sharp teeth.

RECOMMENDATION: Provide an additional TAGS paper jam tool with a larger surface area and less sharp teeth.

7. MPS

On orbit, the LH2 manifold pressures were considerably higher than predicted after the first vacuum inerting, ranging from 10-16 psi. A second vacuum inerting was performed after OMS-2.

8. PHOTO/TV

The CCTV system functioned normally with two noted exceptions. The payload bay camera A would not focus. When focusing was attempted, the crew heard a thumping sound on the 576 bulkhead that was apparently coming from the camera. The RMS wrist camera exhibited a transient problem where the gamma control could not be transferred from manual to automatic control. A power cycle of the camera fixed the problem.

One VTR tape became doubled up on itself when it was rewound in the VTR. The tape cassette was opened and the tape was manually rewound using the power screwdriver. It appeared that the free play of the reels in the cassette allowed slack in the tape and that the slack tape was caught by the pie-shaped cutout in the side reel. The VTR cassettes need to be modified to prevent the tapes from becoming slack inside the cassette.

RECOMMENDATION: Build in a snubber mechanism in the VTR tapes to prevent the reels from drifting in weightlessness, allowing slack and excess tape to accumulate.

The Linhoff camera was flown on this flight. It was an excellent camera and it provided outstanding large format pictures. It should be flown whenever possible. It was found that the 90 mm lens was used almost exclusively. It is recommended that, if feasible and at the crews option, the 250 mm lens be replaced by a third film magazine.

RECOMMENDATION: (A) Crews should request the Linhoff camera whenever stowage and performance allow. (B) Unless specific mission objectives require the 250 mm lens, carry a third film magazine in place of the 250 mm lens.

The 70 mm Hasselblad cameras operated flawlessly; however, postflight analysis indicated that occasionally they would skip a frame of film. 70 mm film was rationed by the crew by the end of flight day two. For missions where feasible and at crews option, additional 70 mm film magazines should be manifested. This is especially important on the high inclination missions which are flown less frequently.

RECOMMENDATION: Increase the number of 70 mm film magazines carried.

One 16 mm Arriflex battery was used for the first nine rolls of film with no noticeable change in operations. The supplemental lighting for in-cabin movies was insufficient for proper exposure of the available films. Enhanced lighting or other high speed film types need to be provided. A major deficiency in the 16 mm camera system was the lack of an adequate "end-of-film" indication. This was not the first time a crew has reported this problem postmission, and it caused the loss of some objectives on this mission.

RECOMMENDATION: (A) Improve the in-cabin capability of the 16 mm motion picture camera system. (B) Improve the "end of film" indication on the 16 mm camera.

Currently, a 35 mm and a 70 mm camera are stowed in A16. With the launch and entry suits and the planned aft movement of the MS-1 seat, access to A16 will be very difficult until well into the mission after the mission specialist seats are removed. These cameras should be moved to another location (possibly A17) to permit more ready access to these cameras.

RECOMMENDATION: Investigate the relocation of cameras carried in A-16 to make them more easily accessible after launch.

V. CREW ESCAPE SYSTEM

A. LES

It is essential for crews in training to get into the LES as early as is practical in the training flow. There was a significant adaptation to the use of the suit; donning, doffing, reach, visibility, and general comfort were all affected. These factors are considerations in the fitting and adjusting of the suits. Crews need to be well down the "curve" when the measurements for the flight suits are established. All of the crew members of STS-27 either switched to larger suits or had their suits expanded in adjustment prior to flight. It is far better to err to the large side in selecting LES sizes.

RECOMMENDATION: Crew members should select LES sizes which maximize the amount of "room" and mobility in the suit.

Since there was a significant amount of adaptation required in the suits, crews should begin as early as possible in their training flow to utilize suits for ascent and entry sessions in the SMS. The commander and pilot felt that four training sessions in the STA were the minimum number to adequately train for the approach and landing task. The crew of STS-27 wore the LES gloves for ascent, but did not wear gloves during entry.

The LES was still marginal as far as cooling is concerned. If the crew compartment can be maintained in the 68-70 degrees F range, and the crew activity is light, then the cooling provided by the suit fans is satisfactory. In warmer or more active situations, the suit was too hot. This was partly because the airflow through the suit is inadequate, as the fans were working against excessive back pressure. A means to pass air through the neck seal is needed. The comfort in the neck seal could be increased if the neck dam material allowed for rotation of the neck in the suit. The present configuration causes chafing of the neck.

RECOMMENDATION: Develop a new neck seal for the LES which reduces chafing and allows for cooling airflow.

B. HARNESS AND PARACHUTE CONTAINER

The parachute risers for the commander were too short and put strain on the shoulders in the launch configuration. The fittings used to connect the harness with the lower part of the parachute container were dangling during ingress and egress. These hooks are snag hazards and should be rigged in some other manner.

RECOMMENDATION: Move the lower harness hooks and straps to the parachute pack, and place the rings on the harness to eliminate snag hazards during ingress and egress.

The STS-27 crew found that launch mobility could be considerably enhanced by removing the velcro patches from the parachute container, allowing the container to shift in the seat as the crew member twisted to reach various panels. For entry, the parachute packs had to be taped to the seats to keep them in place prior to crewman ingress. To preclude this, the velcro tabs should be retained on the parachute pack, and the crew should apply stick-on velcro to the seat prior to deorbit prep.

RECOMMENDATION: Retain the velcro tabs on the parachute container for seat positioning, but remove the velcro from the seat. Crews should apply stick-on velcro to the seat prior to entry.

C. ESCAPE POLE AND SLIDE

The configuration of the escape pole on the middeck provided no significant problems for launch, orbit, or entry operations. Rigging the pole to the overhead in the postinsertion period, and setting it up again prior to deorbit burn was as briefed in the prelaunch training. The escape slide package and its location had no impact on the mission.

VI. Habitability

Changes in Orbiter accommodations to improve habitability were several and have significantly enhanced the crew's ability to accomplish the mission. Among these changes was the window shades in the forward cabin windows. These are simple to extend and retract and have increased the utility to the extent that the pilot extended a window shade on W6 for part of the reentry. The changes made in the WCS have likewise been very beneficial and result in a very smooth operation. The cabin filters were cleaned on flight day two and contained a minimal amount of debris with the exception of the WCS compartment inlet screen which had more lint than other filters. The quick access panels such as those for the Display Electronics Unit boxes and Display Driver Unit 3 on Panels L8, R9, L17, and R17 are excellent and truly facilitate on-orbit maintenance and screen cleaning. Atlantis carried a mix of old and new style lockers on STS-27. The crew was very impressed with the ease of operation of the new locker latch, particularly when compared to the old style latch. The old style continues to be a problem for crews to latch for entry. They are very time consuming to fasten, and there were approximately six latches which could not be secured on STS-27. Considering that there were only about half the number of old style lockers aboard, this is a significant problem. The crew was very much in favor of eliminating the old style locker entirely.

RECOMMENDATION: Convert all on-board lockers to the new latch.

This crew carried too much fresh fruit and did not eat all of it. Fruit which was not consumed or disposed of in the first one and one half days began to "flavor" other foods on board, particularly wheat thins, with their aroma. Bananas and apples were particularly notable for this, and crews should carry no more fresh fruit than they can dispose of in the first two days.

RECOMMENDATION: Constrain the amount of fresh fruit (particularly apples and bananas) to that amount which will definitely be consumed within the first one and one-half days.

VII. DEORBIT AND LANDING

A. DEORBIT PREPARATION

This crew had the luxury of an extra hour in the timeline after wake up, with the deorbit burn scheduled at eight hours after wake up. This allowed four hours for postsleep and prior to entering the deorbit prep checklist, so the crew utilized the time to configure the mission specialist seats, as well as stow all the return to Houston bags on the middeck, and close the airlock. The crew dressed in their LES thermal underwear and selected full cool on the cabin temperature during postsleep. This resulted in a very cold cabin by the time the crew put on the suits for entry which greatly improved the comfort level in the suits. The STS-27 crew completed all of the deorbit prep checklist prior to suit up, which made it far easier to perform checklist items such as the pictorial panel configuration steps. The crew began suit up with the commander and pilot at approximately TIG-one hour, 25 minutes, and seat ingress was completed immediately after. Even with the extra hour in the timeline and the deorbit prep items which had been completed earlier, the crew still found themselves somewhat rushed at this point and could only perform a brief entry review prior to entering the entry checklist at TIG-45 minutes. A new procedure since STS 61-C is to turn off the RCS jet heaters on panel A14 at approximately TIG-10 minutes. Since the flight deck crew members were all strapped in to their seats by this time, this step was performed by the middeck crewman, who was not yet strapped into his seat. All of the members of the crew did the full fluid loading of 32 ounces of fluid and eight salt tablets prior to entry. It was felt desirable to fill several extra drink containers so that there would be water available for the crew postlanding and prior to the arrival of the crew surgeon in the Orbiter.

RECOMMENDATION: Crews should fill several extra drink containers to have water or drinks available postlanding.

B. DEORBIT

Entry checklist procedures were performed without any anomalies and the deorbit burn was initiated on time at 4/07:59:00 MET. The burn was a normal two engine burn of 3 minutes, 31 seconds duration. The crew left their suit visors open for all of the deorbit prep, entry, and landing with their gloves available, but not worn.

C. ENTRY

Activities postdeorbit burn were completely normal, and Atlantis arrived at 400,000 feet altitude (EI) at a MET of 4/08:34:45. The entry was flown completely in daylight conditions, and entry glow effects were minimal through the forward windows, but were quite obvious at the overhead window. The present window shades are of excellent utility and the shade on window W6 was extended by the pilot since the sun was shining through that window anytime the Orbiter was flying a left turn maneuver. The shade was retracted prior to reaching Terminal Area Energy Management (TAEM). The entry was a descending node trajectory and the Orbiter's flight path brought it over Western Canada and on a southeasterly heading over the West Coast of the United States. During entry, the crew noted that the Surface Position Indicated (SPI) gauge showed a constant rudder deflection of 4 degrees left with a continuous "off" flag visible. Other than these two anomalies, the remainder of the SPI functioned properly, and the entire SPI had functioned properly during flight control system checkout the previous day.

The entry progressed very normally until a velocity approaching 16,000 fps. At that point, the Orbiter developed an apparent mismatch between the expected drag profile and the actual drag encountered. Drag peaked at nearly 35 fps^2 accompanied by a peak g load of 1.61 at 16,000 fps (see figure 3 in appendix). Since this value of drag exceeded that expected during the constant drag phase (33 fps^2), it appeared to the crew that the drag and g levels were excessive since they were only one third of the way through the TRAJ 2 display (17014-14002 FPS) and the drag levels indicated on that display did not correspond well to the present drag level. This was further backed up by a significant mismatch between the Orbiter symbol and the guidance box on the display. In actuality, 16,000 fps was the expected point at which the Orbiter would intercept the constant drag phase of entry for this 57 degree inclination mission. Lower inclination and lower energy missions do not encounter the constant drag phase until approximately 14,800 fps which is very close to the transition point between TRAJ 2 and TRAJ 3 (14,002 fps). An additional complication was the fact that a significant variation in local density, an 18 percent increase, was encountered simultaneously with intercepting constant drag at 16,000 fps (see Figure 4 in appendix). This was largely responsible for the overshoot experienced in drag level and g level and resulted in significant Orbiter maneuvering to arrive back at the proper drag levels. Angle of attack was slowly reduced to 37 degrees which reduced the drag to 32 fps^2 within 30 seconds of the drag peak. Bank angle was reduced from nearly 70 degrees to approximately 50 degrees (Figure 5 in appendix) which reduced altitude rate (H-dot) from 180 fps to nearly zero (less than 20 fps) (See Figure 6 in appendix). These maneuvers had nearly corrected the drag mismatch about 45 seconds after the peak drag, when the first roll reversal was commanded at 14,550 fps. Since this reversal was initiated at such a low H-dot, the Orbiter "ballooned" to an H-dot of over +100 fps during the roll reversal. Due to these combined affects, Atlantis did not arrive back on the targeted drag profile until slightly over 13,000 fps or nearly two minutes after the drag peak. Postflight analysis and the crew observations indicate that guidance responded correctly to this situation with only a minor trajectory impact. The anomaly is discussed in detail in this report to document the occurrence and to remind crews that density shears can cause unusual Orbiter responses which may require several minutes to effect a complete recovery to the nominal trajectory.

This mission was unique in that there was no blackout phase during reentry since communications could be maintained from the Orbiter's upper antennas to the TDRS-C satellite.

D. LANDING

TAEM and the change to major mode 305 occurred at MET 4/08:59:14 at close to nominal conditions. A pull up maneuver was initiated by auto guidance to ensure that the Orbiter would intercept the HAC at less than Mach 1. The pilot selected CSS at .924 Mach and flew the initial HAC intercept at .91 Mach. The commander assumed control after passing overhead the landing runway on the 315 degree HAC turn. The approach and landing proceeded normally and main gear touchdown occurred at MET 4/09:05:37 at 198 KEAS at a sink rate of .28 fps. Derotation was commanded at 185 KEAS and nose landing gear touchdown occurred seven seconds after main gear touchdown with an Orbiter pitch rate of 3.0 degrees per second at touchdown.

This flight included braking and NWS DTO's so braking was initiated at 132 knots ground speed. The NWS test was begun at 100 knots and consisted of steering to 30 feet off centerline and back to center using the GPC mode of NWS. Performing these two tasks simultaneously was difficult to do accurately and the deceleration rate varied as a result. Wheel stop occurred at MET 4/09:06:18 after a ground roll of 7123 feet. (Touchdown at 1469 feet, wheel stop at 8592 feet).

E. POSTLANDING

A normal postlanding timeframe occurred and the crew changed to flight suits which were carried aboard by the exchange crew. The cabin was quite warm postlanding in spite of the significant chill-down that the crew had performed during deorbit prep, and all the crew members were eager for the drinking water brought aboard by the crew surgeon.

After egressing the cabin, the crew inspected the very significant tile damage which had occurred to Atlantis. There were 707 total impact sites, of which 298 were over one inch in diameter, the most severe tile damage experienced on any flight. The majority of these occurred on the right chine area aft to the right wing, with only eight impact sites on the left side of the Orbiter. An entire tile was lost (V070-391015-193) from the right fuselage at station Xo-390, Yo-60 which resulted in some melting of the tin plated aluminum panel under this tile. An Advanced Flexible Reusable Surface Insulation (AFRSI) fiberglass carrier panel (V070-396403-002) was lost from the right OMS Pod during the flight, probably due to incorrect installation. No heat damage occurred due to this panel's location in a reduced heating area.

STS-27 FLIGHT CREW REPORT RECOMMENDATIONS

1. **RECOMMENDATION:** Do not conduct press conferences in any form for DOD crews.

2. **RECOMMENDATION:** Maintain the SMS aft visual system to maximize the clarity and utility of the scenes. Expedite the upgrade and replacement of the aft visual system.

3. **RECOMMENDATION:** Continue the use of the SES and SIMFAC facilities to provide RMS dynamic training in the RMS core syllabus.

4. **RECOMMENDATION:** Maximize the accuracy of the drawings in the cargo systems manual (within security limitation), and ensure that EVA related issues are decided based on flight hardware.

5. **RECOMMENDATION:** Continue night suited training in the M113 armored personnel carrier.

6. **RECOMMENDATION:** Include a long simulation on missions which are significantly different or complicated over prior flights.

7. **RECOMMENDATION:** Continue to perform a TCDT for every launch.

8. **RECOMMENDATION:** Include all ascent FDF stowage items for TCDT.

9. **RECOMMENDATION:** Fix the video tape recorder and the satellite dish systems in the JSC crew quarters.

10. **RECOMMENDATION:** Do not use the hallways or lounge areas in the KSC crew quarters for conferences during crew sleep periods. Utilize the conference room or office space.

11. **RECOMMENDATION:** Continue the Family Support Plan on all future missions.

12. **RECOMMENDATION:** To preclude losing pens and pencils during orbit ingress, do not store pens or pencils in the leg pockets of the suit. Add a velcro flap to these pockets if they must be used.

13. **RECOMMENDATION:** Mark "no step" areas of the Orbiter cabin for ingress.

14. **RECOMMENDATION:** Provide handholds for the middeck seated crewman to assist in seat ingress and improve mobility.

15. **RECOMMENDATION:** Provide a middeck "swizzle stick" for MS-3 to aid in prelaunch troubleshooting.

16. **RECOMMENDATION:** The Orbiter commander or pilot should wear an EVA wrist mirror to assist in reading TACAN or MLS channels prelaunch.

17. **RECOMMENDATION:** Continue to support launches with weather observers airborne at the TAL sites.

18. **RECOMMENDATION:** Include an additional seat belt strap to restrain the lap belt and crew member down in the seat.

19. **RECOMMENDATION:** Continue to utilize the portable tape recorder to record on-board ICOM and Air to Ground for launch.

20. **RECOMMENDATION:** Increase the size of the helmet bags to fit the LES helmets.

21. **RECOMMENDATION:** Include all planned secondary payload operations in crew training requirements.

22. **RECOMMENDATION:** All RMS operators should be made aware of the differences in the flight and simulator brake switch feel. The switch should be lockable in both the ON and OFF positions.

23. **RECOMMENDATION:** Provide a synoptic view of the Orbiter with the areas being surveyed highlighted in some manner, e.g., with shading for use during RMS tile surveys.

24. **RECOMMENDATION:** For any of the RMS surveys where a joint is being moved without direct or indirect crew visibility, provide the approximate clearance between the moving part of the arm and Orbiter.

25. **RECOMMENDATION:** Modify the RMS tile survey procedures so that they list the maximum allowable ranges of wrist joints at a given location.

26. **RECOMMENDATION:** Add the stowed MPM survey procedure to the PDRS checklist.

27. **RECOMMENDATION:** Add the OMS pod and tail surface surveys to the PDRS checklist.

28. **RECOMMENDATION:** Do not utilize secure television to downlink video data for damage analysis when resolution is critical. Ensure that crew comments are included in damage assessments.

29. **RECOMMENDATION:** Include an additional vacuum hose attachment with a 30-40 degree angled tip for free water disposal.

30. **RECOMMENDATION:** Fly a more powerful power screwdriver.

31. **RECOMMENDATION:** Investigate the feasibility of standardizing schematics on Orbiter panels, SSSH Drawing, pocket checklists and malfunction procedures, and the IFM manual.

32. **RECOMMENDATION:** Examine modifications to the humidity separators, cabin fans, IMU fans, water pumps, and other ECLSS components which will allow for limited on-orbit servicing and repair.

33. **RECOMMENDATION:** Crews should reduce cabin temperature markedly during deorbit prep to enhance comfort in the suits.

34. **RECOMMENDATION:** Continue the communication checks from MCC to each crew member as they complete strap in.

35. **RECOMMENDATION:** Do not rely on STVS video to perform damage assessments.

36. **RECOMMENDATION:** Provide an additional TAGS paper jam tool with a larger surface area and less sharp teeth.

37. **RECOMMENDATION:** Build in a snubber mechanism in the VTR tapes to prevent the reels from drifting in weightlessness, allowing slack and excess tape to accumulate.

38. **RECOMMENDATION:** (A) Crews should request the Linhoff camera whenever stowage and performance allow. (B) Unless specific mission objectives require the 250 mm lens, carry a third film magazine in place of the 250 mm lens.

39. **RECOMMENDATION:** (A) Improve the in-cabin capability of the 16 mm motion picture camera system. (B) Improve the "end of film" indication on the 16 mm camera.

40. **RECOMMENDATION:** Investigate the relocation of cameras carried in A-16 to make them more easily accessible after launch.

41. **RECOMMENDATION:** Crew members should select LES sizes which maximize the amount of "room" and mobility in the suit.

42. **RECOMMENDATION:** Develop a new neck seal for the LES which reduces chafing and allows for cooling airflow.

43. **RECOMMENDATION:** Move the lower harness hooks and straps to the parachute pack, and place the rings on the harness to eliminate snag hazards during ingress and egress.

44. **RECOMMENDATION:** Retain the velcro tabs on the parachute container for seat positioning, but remove the velcro from the seat. Crews should apply stick-on velcro to the seat prior to entry.

45. **RECOMMENDATION:** Convert all on-board lockers to the new latch.

46. **RECOMMENDATION:** Constrain the amount of fresh fruit (particularly apples and bananas) to that amount which will definitely be consumed within the first one and one-half days.

47. **RECOMMENDATION:** Crews should fill several extra drink containers to have water or drinks available postlanding.

ACRONYM LIST

AFB	Air Force Base
AFRSI	Advanced Flexible Reusable Surface Insulation
AMOS	Air Force Main Optical Site
APC	Armored Personnel Carrier
APE	Auroral Photography Experiment
APU	Auxilliary Power Unit
ASP	Astronaut Support Person
AV	Avionics
CAP	Crew Activity Plan
CCTV	Closed Circuit Television
CEIT	Crew Equipment Integration Test
CIR	Cargo Integration Review
COAS	Course Optical Alignment Sight
CRUX	Cosmic Ray Upset Experiment
CSS	Control Stick Steering
DIG	Digital Image Generator
DOD	Department of Defense
DSO	Detailed Supplementary Objective
DTO	Detailed Test Objective
ECLSS	Environmental Control and Life Support
EI	Entry Interface
ET	External Tank
EST	Eastern Standard Time
EVA	Extravehicular Activity
FDF	Flight Data File

FOR	Flight Operations Review
FPS	Feet Per Second
GG	Gas Generator
GNC	Guidance Navigation & Control
GPC	General Purpose Computer
GSE	Ground Support Equipment
H2	Hydrogen
HAC	Heading Alignment Cone
HIU	Headset Interface Unit
ICOM	Intercommunications
IFM	In Flight Maintenance
IUS	Inertial Upper Stage
IVT	Interface Verification Team
JSC	Johnson Space Center
KSC	Kennedy Space Center
KEAS	Knots Equivalent Airspeed
LCC	Launch Control Center
LEH	Launch/Entry Helmet
LES	Launch/Entry Suits
LH2	Liquid Hydrogen
LIOH	Lithium Hydroxide
LRU	Line Replaceable Unit
MCC	Misson Control Center
MECO	Main Engine Cut Off
MET	Mission Elapsed Time
MLS	Microwave Landing System
MM	Millimeter

MPM	Manipulator Positioning Mechanism
MPS	Main Propulsion System
MS	Mission Specialist
NM	Nautical Miles
NWS	Nosewheel Steering
OASIS	Orbiter Autonomous Supporting Instrumentation System
OMS	Orbital Maneuvering Subsystem
OPS	Operations
OV	Orbiter Vehicle
PAM	Payload Assist Module
PDRS	Payload Deployment and Retrieval System
PPO2	Partial Pressure 02
PSI	Pounds Per Square Inch
RCS	Reaction Control System
RME	Radiation Monitoring Experiment
RMS	Remote Manipulator System
SES	Shuttle Engineering Simulator
SIMFAC	SPAR Aerospace in Canada
SMS	Shuttle Mission Simulator
SN	Serial Number
SPI	Surface Position Indicator
SRB	Solid Rocket Booster
SSSH	Space Shuttle Systems Handbook
STA	Shuttle Training Aircraft
STVS	Secure Television System
STS	Space Transportation System
TACAN	Tactical Air Navigation

TAEM	Terminal Area Energy Management
TAGS	Text and Graphics System
TAL	Trans Atlantic Landing
TCDT	Terminal Countdown Demonstration Test
TDRS	Tracking and Data Relay Satellite
TIG	Time of Ignition
TPS	Thermal Protection System
TV	Television
VFT	Visual Function Test Device
VITT	Vehicle Integration Test Team
VTR	Video Tape Recorder
WCS	Waste Control System
WETF	Weightless Environmental Testing Facility

X. APPENDIX

(See attached)

GN&C
STS-027

V98R1550C
(UNITS N/A)

- VIBRATION CAUSED BY PAYLOAD
-
- AUTO TRIM HAS SOME NEGATIVES

V98R1551C
(UNITS N/A)

V98R1552C
(UNITS N/A)

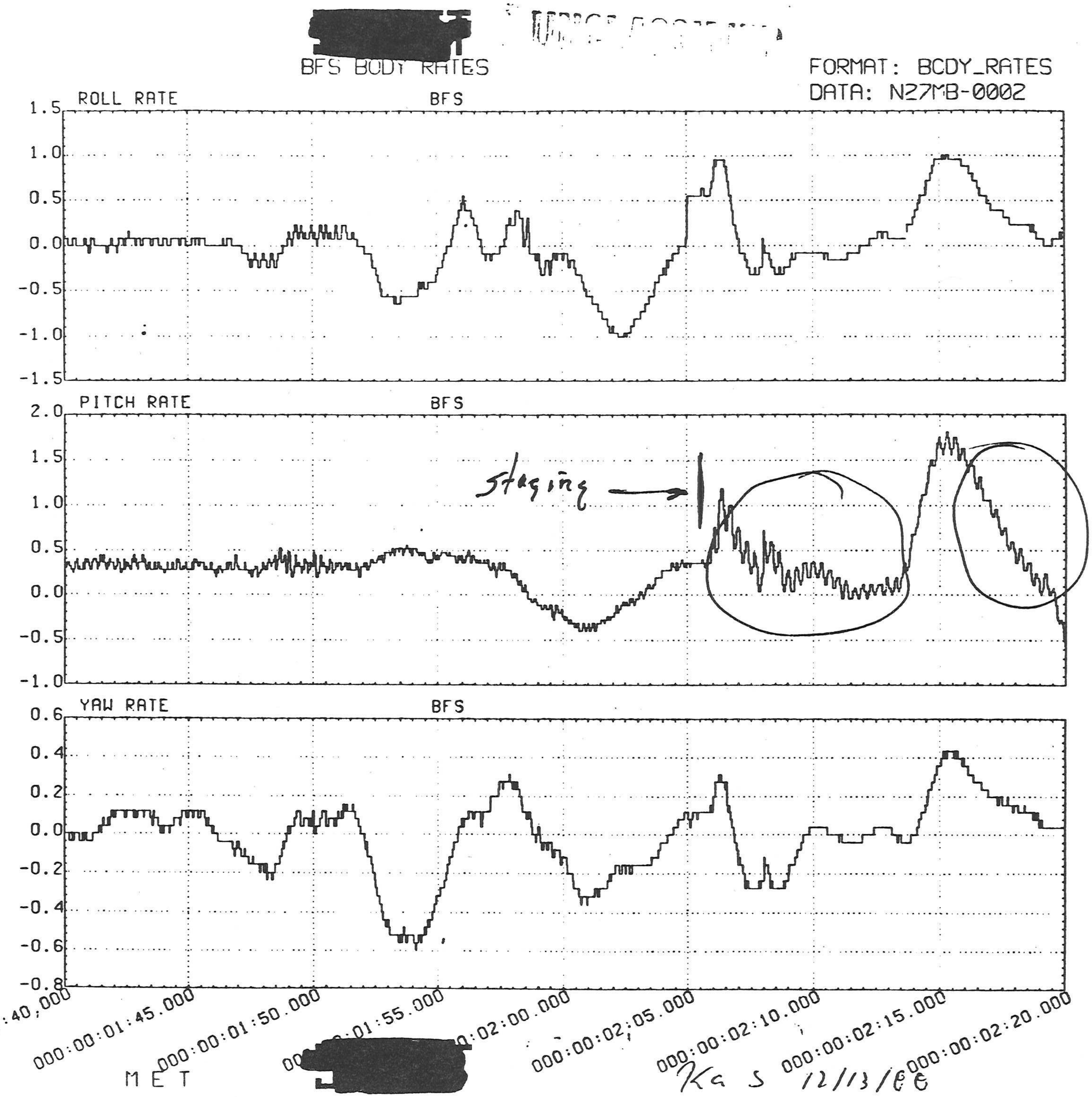


FIGURE 1

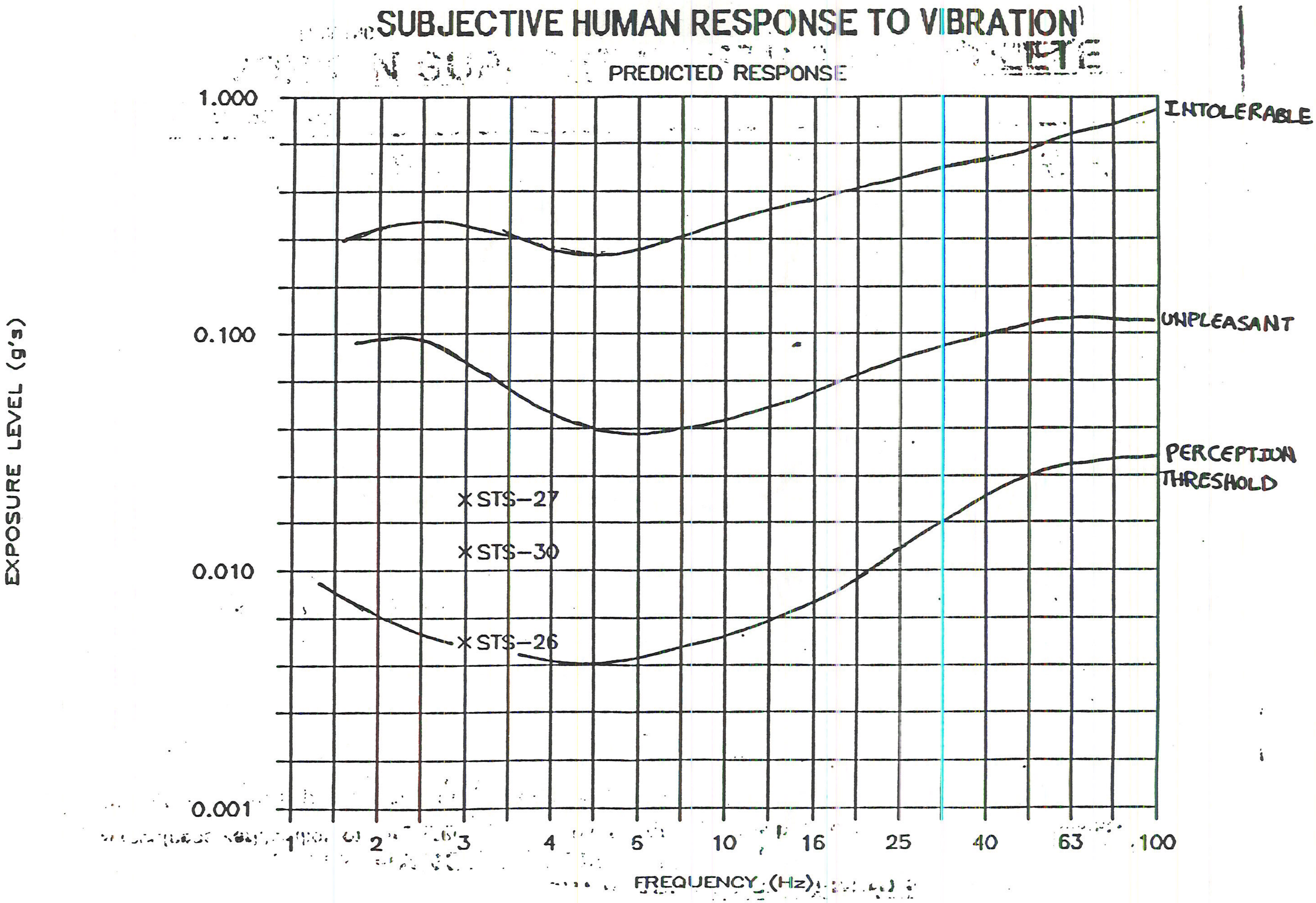

SUBJECTIVE HUMAN RESPONSE TO VIBRATION
PREDICTED RESPONSE
1.000
0.100
0.010
0.001
EXPOSURE LEVEL (g's)
INTOLERABLE
UNPLEASANT
PERCEPTION THRESHOLD
× STS-27
× STS-30
× STS-26
1
2
3
4
6
10
16
25
40
63
100
FREQUENCY (Hz)

FIGURE 2

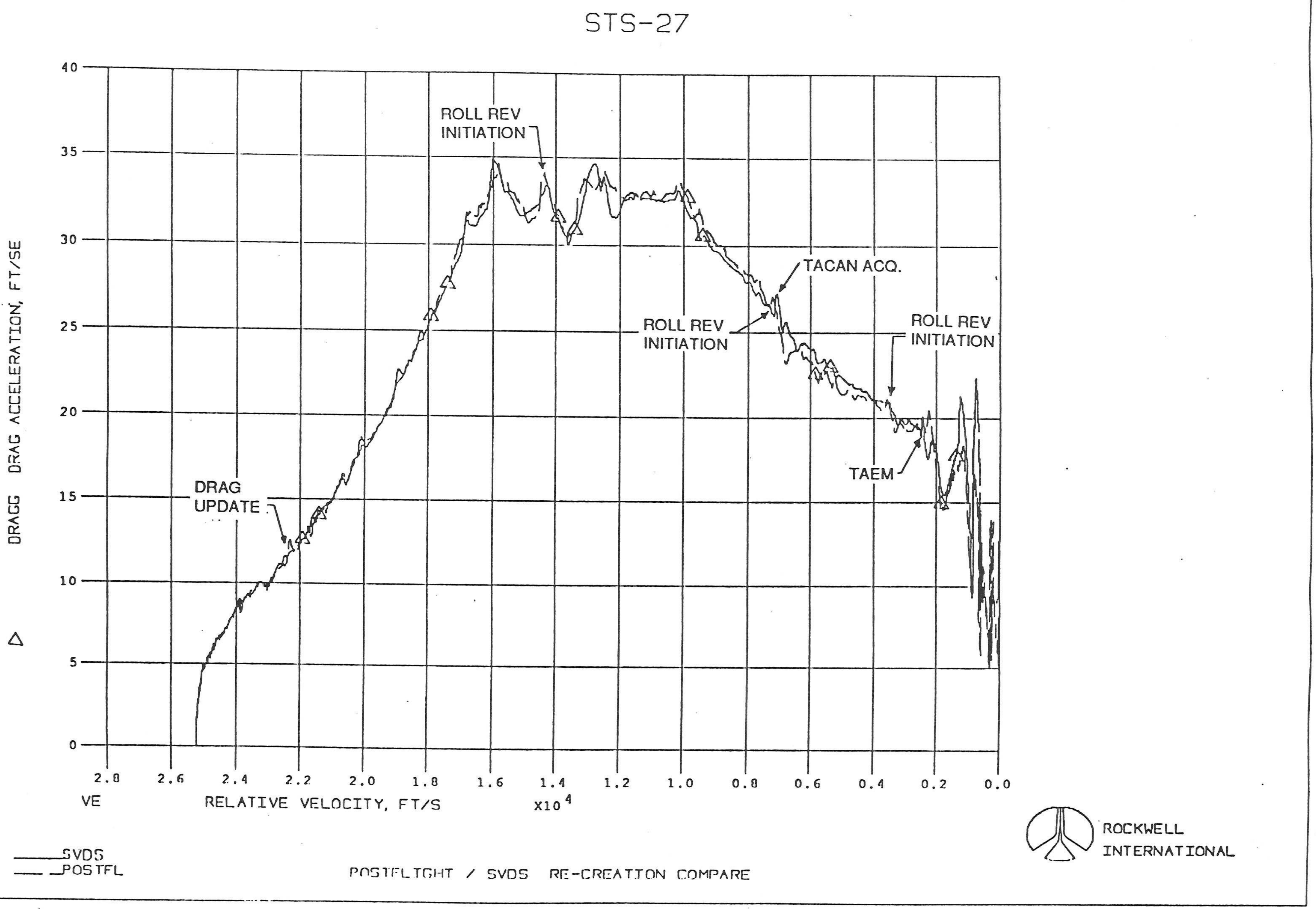

STS-27
40
35
30
25
20
15
10
5
0
DRAGG DRAG ACCELERATION, FT/SE
Δ
ROLL REV INITIATION
ROLL REV INITIATION
TACAN ACQ.
ROLL REV INITIATION
ROLL REV INITIATION
TAEM
DRAG UPDATE
2.8 2.6 2.4 2.2 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0
VE
RELATIVE VELOCITY, FT/S
X10 4
SVDS
POSTFL
POSTFLIGHT / SVDS RE-CREATION COMPARE
ROCKWELL INTERNATIONAL

FIGURE 3

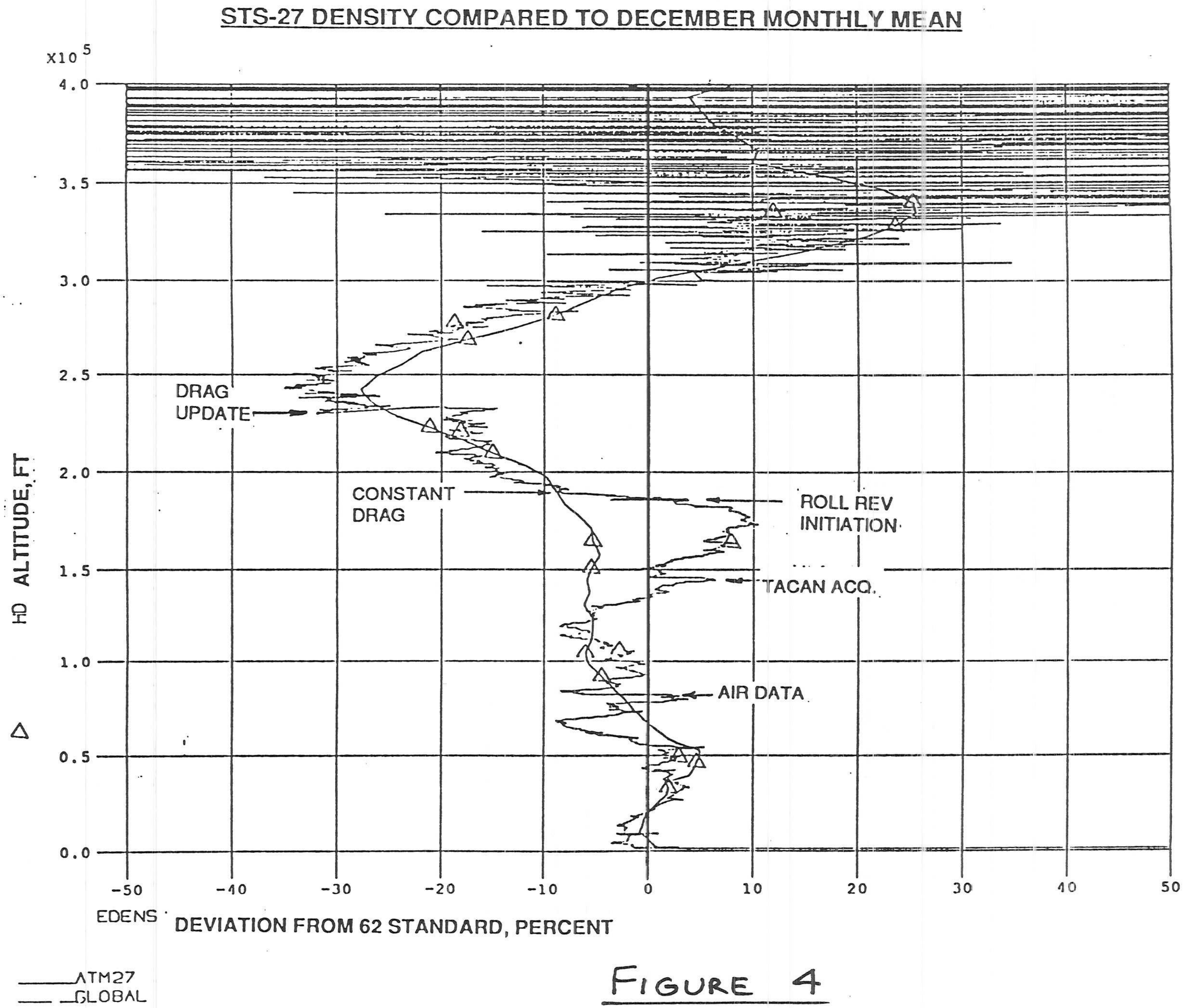
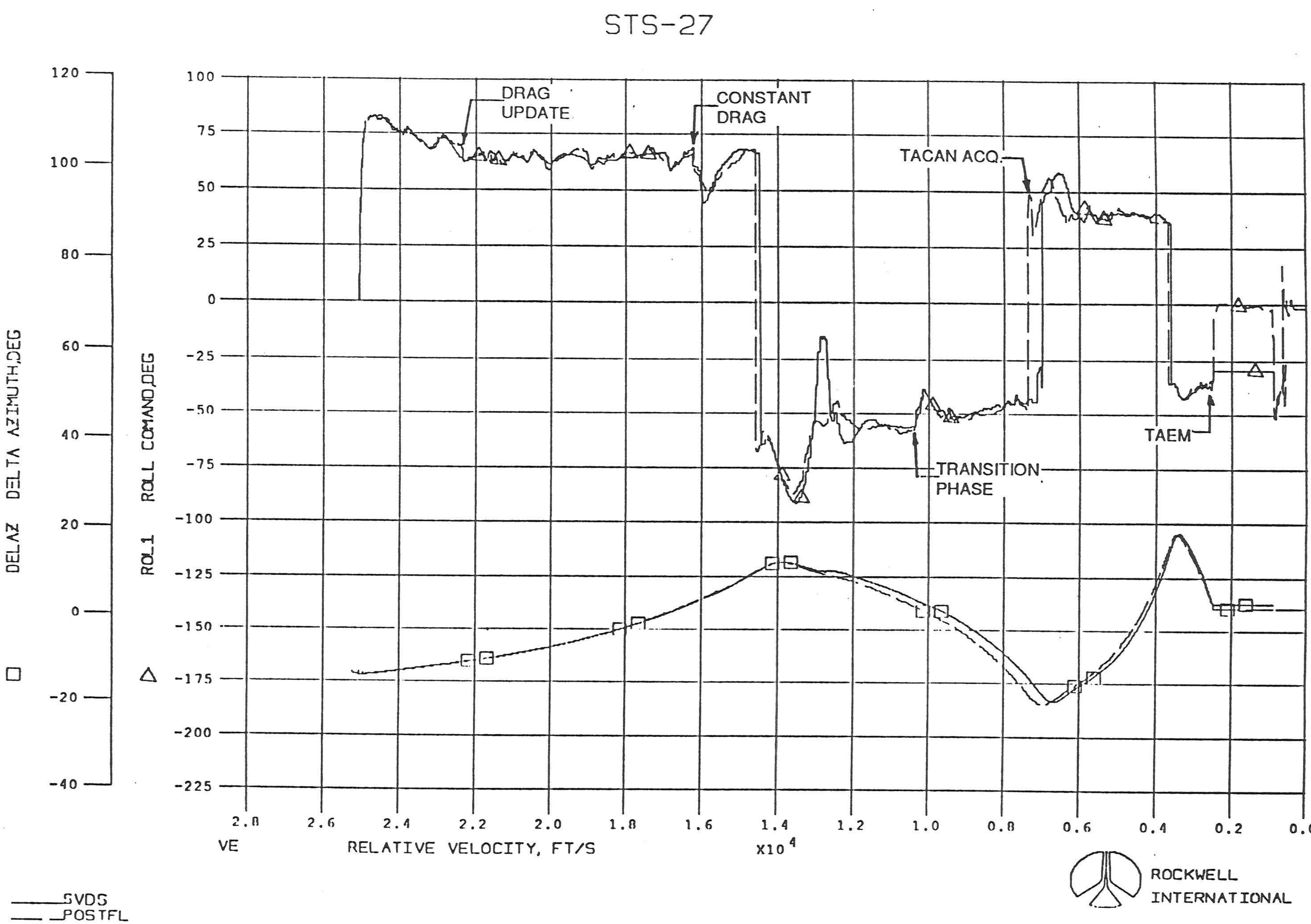


FIGURE 4

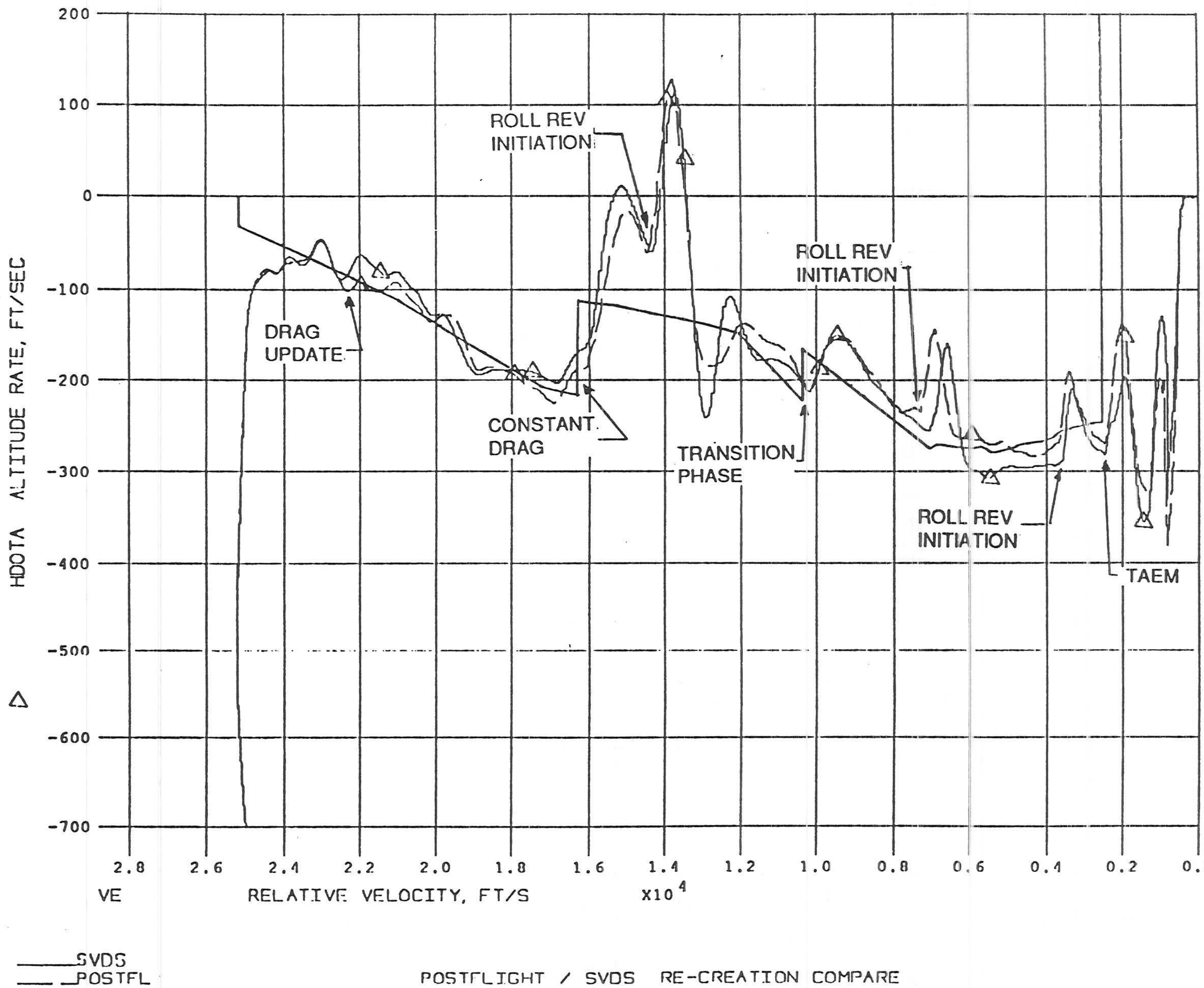
NASA
JOHNSON SPACE CENTER
DM35 / R SILVESTRI 403-0030
021009 @ 1606



STS-27
DRAG
UPDATE
CONSTANT
DRAG
TACAN ACQ.
TRANSITION
PHASE
TAEM
120
100
80
60
40
20
0
-20
-40
100
75
50
25
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
DELAZ DELTA AZIMUTH,DEG
ROL1 ROLL COMAND,DEG
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
VE
RELATIVE VELOCITY, FT/S
X10^4
SVDS
POSTFL
ROCKWELL
INTERNATIONAL

FIGURE 5

STS-27



POSTFLIGHT / SVDS RE-CREATION COMPARE

ROCKWELL INTERNATIONAL

FIGURE 6

cc:
NASA Headquarters
A/R. M. Truly
M/G. W. S. Abbey
M/A. D. Aldrich

Kennedy Space Center
CD/F. S. McCartney
MK/R. L. Crippen

Marshall Space Flight Center
DA01/T. J. Lee

Johnson Space Center
AA/A. Cohen
AB/P. J. Weitz
AC/D. A. Nebrig
AC5/J. W. Young
CA/R. W. Nygren
CA2/R. C. Zwieg
CA4/O. J. Bertrand
CA8/D. J. Bourque (3)
CB/M. S. Sanchez
CB/All Astronauts (100)
CC/J. S. Algranti
CC5/C. F. Hayes
DA/E. F. Kranz
DA8/L. S. Bourgeois
DC/K. W. Russell (5)
DF/S. G. Bales (5)
DG/R. K. Holkan (10)
DH/E. L. Pavelka (5)
DM/J. C. Harpold (2)
EA/H. O. Pohl
EC/W. W. Guy
EH/K. J. Cox
EP/C. A. Vaughn
ES111/D. C. Wade
EX/W. E. Milligan
FA/R. L. Berry (4)
FM/E. C. Lineberry
FR/S. G. House
FS/J. W. Seyl
NSTS-GA/L. S. Nicholson (2)
NSTS-GA/J. H. Greene
NA/C. S. Harlan
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SA/C. L. Huntoon (2)
SD/S. L. Pool
SP/C. D. Perner (5)
TA/C. H. Lambert, Jr.(2)
TC3/R. G. Zedekar
TC4/J. C. O'Loughlin
VA/R. A. Collonna (4)
VA/D. M. Germany
VF/J. E. Mechelay (2)
WA/L. Williams (3)