

STS-3 GNC POST FLIGHT REPORT

Attached is the GNC STS-3 post flight report. The report is broken into four control system areas, one significant FTO, and sixteen individual hardware subsystems. Each report is divided into a system performance which includes an anomaly analysis, lesson learned, and a recommendations section. It is intended that this report become a working document as a reference for future system evaluation.

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## Ascent DAP

### A. Performance

The performance of the Ascent DAP was entirely nominal. SSME and SRB thrust vector control performed correctly in response to guidance and GC steer commands. Elevon load relief was nominal. On flight 3 we again had a slight amount of lofting during the first stage. After flight 2 E&D changed some of the I-load guidance parameters in order to reduce the ADI pitch errors during the first stage. The parameters that were changed are NZ REF and SRB trims.

#### 1. Anomalies

There were no problems identified that can be attributed to the Ascent DAP.

#### 2. Comparison of STS-2 and STS-3 Data

On STS-2 the ADI pitch attitude error pegged-out at 5 degrees during the first stage. On STS-3 the pitch error briefly reached three degrees at one point, but was less than two degrees for most of the first stage. The improvement in pitch error on flight 3 is due to the guidance I-load changes. E&D does not plan to make any further adjustments to these parameters for subsequent flights.

### B. Lessons Learned - NONE

### C. Recommendations for Subsequent Activities

1. LCC Limit Changes - Not applicable because LCC does not address flight software.
2. Flight Rules Changes - Not applicable because there are no defined failure modes of flight software.
3. SMS Parameter/Model Changes - NONE
4. Console or MCC Procedure Changes - NONE
5. Data Retrieval Adequacy - NONE



## ORBIT DAP

### I. PERFORMANCE

#### A. Minimum Attitude Deadband Tests

1. .033 deg - The Orbit DAP had no problems controlling to a .033 deg. deadband. No phase plane overshoots occurred due to the fact that the DISC RATE was .016 deg/sec. Had the RATE been the nominal .2 deg/sec, there probably would have been more jet activity in addition to overshoots. See Figure 1.
2. .01 deg - As seen in Figure 2 the DAP had more difficulty controlling to a .01 deg deadband. It did, however, control to this small deadband but with significantly more jet activity. Preliminary reports indicate a fuel usage rate of  $\sim 1.5$  lbm/min. This test should be considered successful since it demonstrated the capability of the DAP to control to an extremely narrow deadband. In the future, however, planners must take into account the high fuel usage. This usage rate agreed fairly closely with pre-flight FSSL runs.

#### B. L5D/R5D Plume Impingement Test

This test was performed to provide E&D with more accurate vehicle angular accelerations due to L5D/R5D jet firings. ACIP data is not yet in so no numbers are available. The procedure was performed correctly however, so the numbers should be good. These angular accelerations will be used to update MAG CONTROL ACCEL and ANGULAR INCREMENT I-Loads which are used by the Phase Plane and the State Estimator respectively. See Figure 3.

- C. L2U Thermal Soakback - It is outside the GNC discipline to evaluate this test. The procedure was, however, performed correctly. F2U was on constantly. L2U was on for  $\sim 95$  sec. total. See Figure 4.

- D. RMS/PRCS Interaction Test - The procedure during part 1 of this test was not performed properly causing deviation from thermal attitude, large torques on the RMS, and extremely high jet activity. The DISC RATE in the procedure was .5 deg/sec. This caused extremely high jet activity. The strip charts were lost post flight, but PROP should be able to verify the increased activity. The rate was used between PRCS pulses to return to the Thermal Test Attitude as fast as possible so that deviation from this attitude would be minimized. The rate however, was excessively high for VRCS with a  $1^{\circ}$  deadband. The result was several Phase Plane overshoots as the DAP slowly zeroed in on the desired attitude. With each overshoot, the DAP would switch from Track to Maneuver. When in the Maneuver mode the DAP accelerates the vehicle to the given DAP RATE. So, one can see that the overshooting led to a series of maneuvers each at a rate of .5 deg/sec. See Figures 5 and 6 for examples of phase plane overshoot during this test. The procedure called for the crew to load a Rotation Start Time far enough in the future so that the maneuver would be completed and stable before the ROT was to start. In part 1 of this test, however, the crew loaded a ROT start time in the past causing immediate initiation of ROT at the current attitude (usually at a point in the middle of the MNVR).



Compounding this, the crew was unaware that a ROT had begun and consequently did not have the DAP configured properly. The result was initiation of a ROT at .5 deg/sec. (See Table 1). The crew performed the Part 2 and loaded test correctly relative to the ROTs and MNVRs. The FDF, however, still called for a DAP RATE of .5 deg/sec. So even for the nominal procedure there were several Phase Plane overshoots causing excessive jet firings and fuel usage. The future ROT time allowed just barely enough time for the MNVR to completely finish before beginning ROT.

On two of the Roll doublets during Part 1 of the test, Yaw was also commanded. See figures 7 & 8. It is interesting to note that both times this occurred the polarities were the same (+Roll, -Yaw). The springs in the aft RHC are half as strong as in the forward RHC, but it is not known if this was the cause or not. It may simply have been that the crew was using the RHC as a brace while floating around. The Yaw deflections did cause extra jets to fire.

E. Thermal FTO Attitude Maintenance - The thermal attitude was maintained very well throughout the flight. At one point, however, the DAP RATE was changed from .135 deg/sec in order to stay within  $10^\circ$  of the Roll attitude. The need to change this number was due to a couple of factors:

1. The period of the orbit was constantly shortening so that no one number would maintain correct Roll phasing for long.
2. For a long period of time of thermal attitude hold, the definition of the center of the phase plane was not accurate enough (i.e. not enough precision to the crew loaded DAP RATE).

Nothing can be done about the orbital period but a more accurate DAP RATE could be entered via a Read/Write on a software change to allow a higher degree of accuracy to be entered by the crew.

Throughout this test, there were several events that caused QBI to be snapped. Each time this occurred the phase plane was recentered about the new attitude. CONTROL calculated the maximum deviation of the +x body axis from the sun vector with each new QBI snap. A SR-59 program was developed Real Time to calculate this maximum error. There was only one time when the max error exceeded 3.0 deg (3.8 deg).

Should a test such as this ever occur again (i.e. a test where Roll angle vs time is important) GNC has been tasked to track the desired attitude; R,P,&Y. We are writing HP9845B program to provide rapid determination of the desired attitude. Currently, however, there is no planned flight with this requirement.

## II. ANALYSIS OF EACH PROBLEM

The most significant problem to occur concerning the Orbit DAP was the phase plane overshoot discussed earlier in PERFORMANCE. This section, therefore, will be devoted to illustrating interesting events that occurred during the flight.

- A. Crew switched to DAP A with a rate of .4 deg/s during auto maneuver from IMU to COAS attitude. MNVR should have been at .2 deg/sec. See figure 9.
- B. During PTC at 06:21:00:00 crew switched from DAP A → DAP B → DAP A (rates = .4 → .2 → .4). See figure 10.
- C. Effects of Payload Bay Door on VRCS DAP with 1 deg. deadband. See figure 11.

### III. COMPARISON OF STS-2 and STS-3 DATA

There were no directly comparable tests between STS-2 and STS-3. The nominal DAP operations (i.e. maneuvering, tracking, etc) showed no differences.

### IV. LESSONS LEARNED

A. The primary lesson learned on STS-3 was not to use a DISC RATE that is too high for a given attitude deadband. The use of a .5 deg/sec rate with a 1 deg deadband was obviously a mismatch (using VRCS). There is no formula for the optimum rate/deadband at present. It was mentioned in the STS-2 report, however, that care must be observed when choosing a particular combination. Some general concerns and guidelines can be set forth here:

1. VRCS is the most sensitive to a mismatch since they lack control authority. An incorrect combination here leads to excessive cycling of an already overworked Vernier control system and high fuel usage.
2. The larger the rate the larger the deadband must be in order to prevent unnecessary auto maneuvers. For example, with a rate of .5 deg/sec a deadband of 3-5 deg would have significantly reduced fuel usage as well as jet cycling.

### V. RECOMMENDATIONS FOR SUBSEQUENT ACTIVITIES

- A. LCC Limit Changes - N/A. Orbit DAP Software is not dependent on LC limits.
- B. Flight Rules Changes - None
- C. SMS Parameter/Model Changes - The SMS model should be examined relative to high VRCS DISC RATE vs small deadband cases. CH4 stated they never saw overshoots of the magnitude seen during all three parts of the RMS/PRCS tests.
- D. Console or MCC Procedure Changes - None
- E. Data Retrieval Accuracy - Regular Thrift deliveries came quicker than STS-2. It took ~ 8 hrs. on STS-3.



Table I

## RMS/PRCS UNLOADED TEST-PART 1

TIME	DAP MODE	ACTIVITY
82:16:25:00	A/AUTO/VERN	ROT
:25:52	B/MAN /NORM	TEST PULSES
27:32	B/A/V	Mnvr back to Thermal Att
28:16	B/A/V	ROT initiated prior to end of Mnvr
30:16	A/A/V	ΔROT at .5°/s ROT-DAP mode switched causing reinit of ROT at .135°/s
31:20	B/M/N	TEST PULSES
33:20	B/A/V	Mnvr back to Thermal Att
33:45	B/A/V	ROT init. prior to Thermal Att (.5°/s)
34:59	A/A/V	ROT-DAP switched to .135°/s
35:51	B/M/N	TEST PULSES
37:26	B/A/V	Mnvr back to Thermal Att
37:43	B/A/V	ROT init. prior to Thermal Att (.5°/s)
40:13	A/A/V	ROT-DAP switched
41:04	B/M/N	TEST PULSES
42:49	B/A/V	Mnvr back to Thermal Att.
43:11	B/A/V	ROT init prior to Thermal Att.



1mm/sec

FIGURE 1

.033 DB

.016 RT

RSD

RSA

LSD

612

70



L5L

R5R

L5L

3.2.5



FIG 1 cont

2



3.2.6

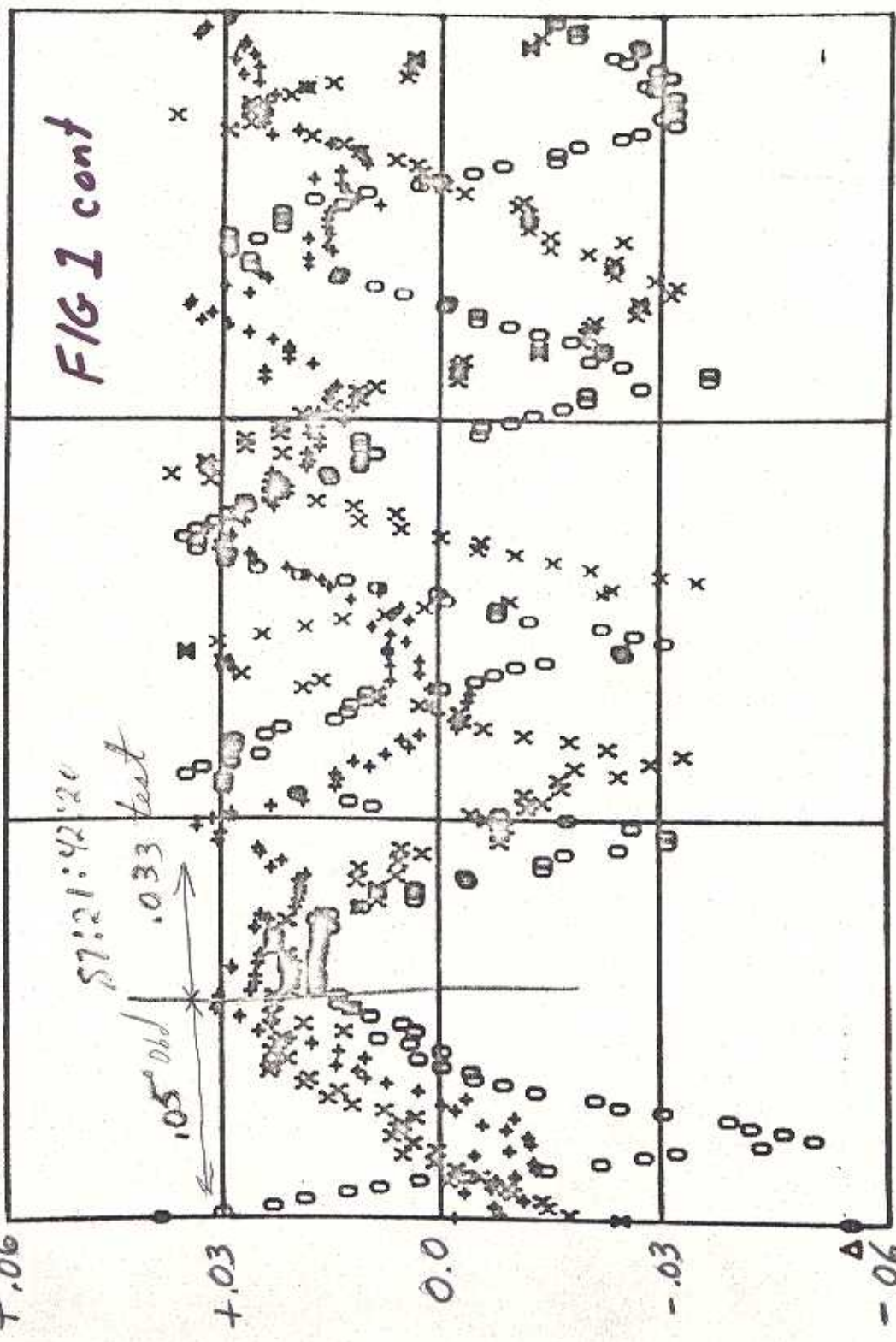


4 DAY 0 8

P11842C

3/102 GNC UP 2  
SEC POINT 180 SITE IOS NCM=

R DAP ERRS P DAP ERRS Y DAP ERRS MED. SCALE  
V90H2143C =XL V90H2141C =DL V90H2142C =+L V72K8505X =AD.  
-0.015 -0.015 0.029  
+0.06



107J 5:58 0GMT= 87:21:41:17 .GND= 88:02:01:41 2 4 6

3.2.10

Y02 H00 ? MIN 0 7 SEC



87:20:22:18.4

87:22:01:45

87:22:00:45

1mm/sec

FIGURE 2

2



0.01 PRS

F5L

F5R

L5L

L5R

R5R

R5D



VRCS JET PCs  
FSR

1.010 Deg Hand Test

Fmt 70  
FSR

MSO

FIG 2cont

(I)



FSL

87:2 2:04:45

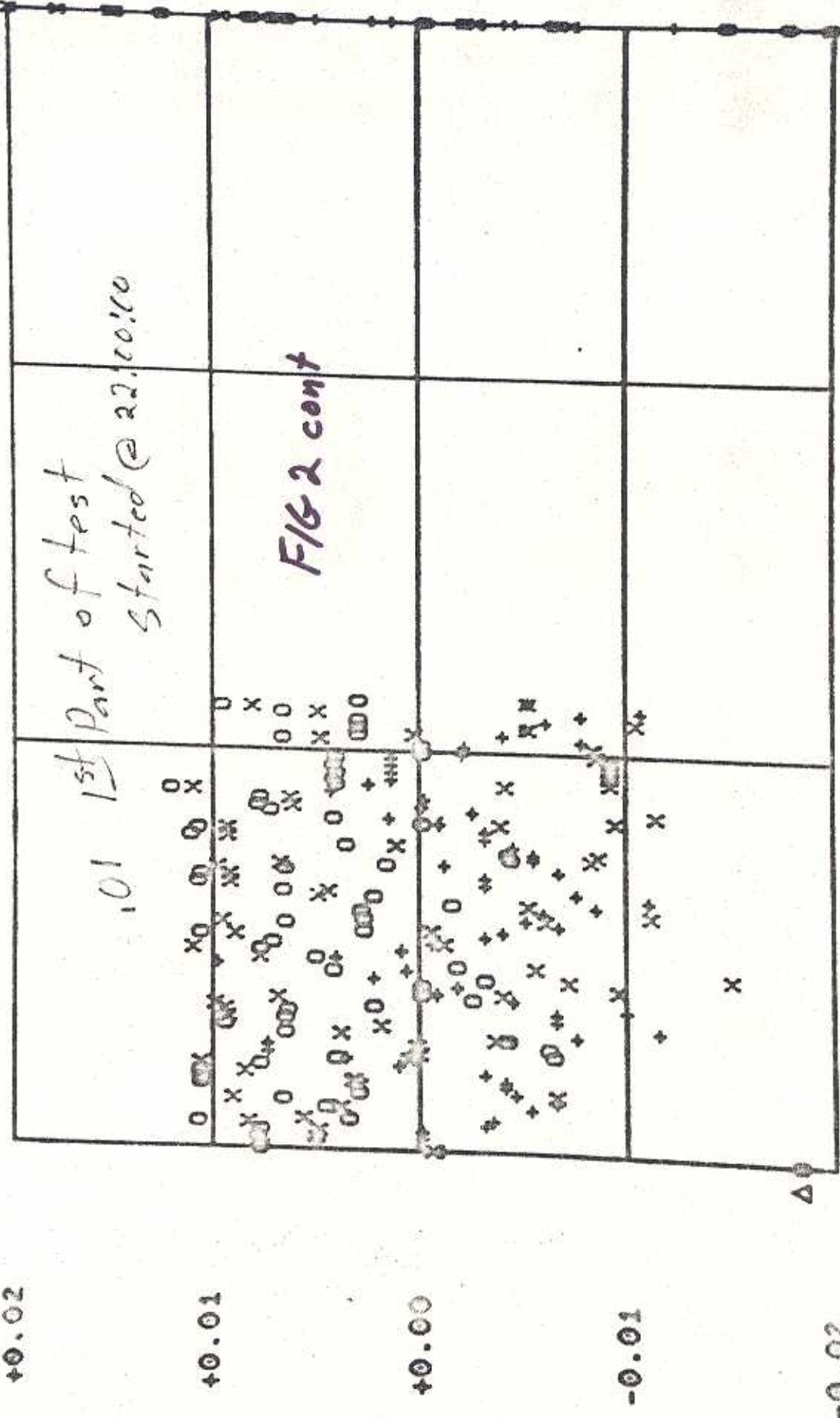
45

87:22:03:

87:22:02:45



F/V 3/102 GNC UP 2 P118420  
 UDRATE 3/2 SEC POINT 85 SITE HAW NOM=  
 R DAP ERRS P DAP ERRS Y DAP ERRS MED SCALE  
 V90H2143C =XL V90H2141C =OL V90H2142C =+L V72K8505X =AD  
 0.044 -0.025 0.006



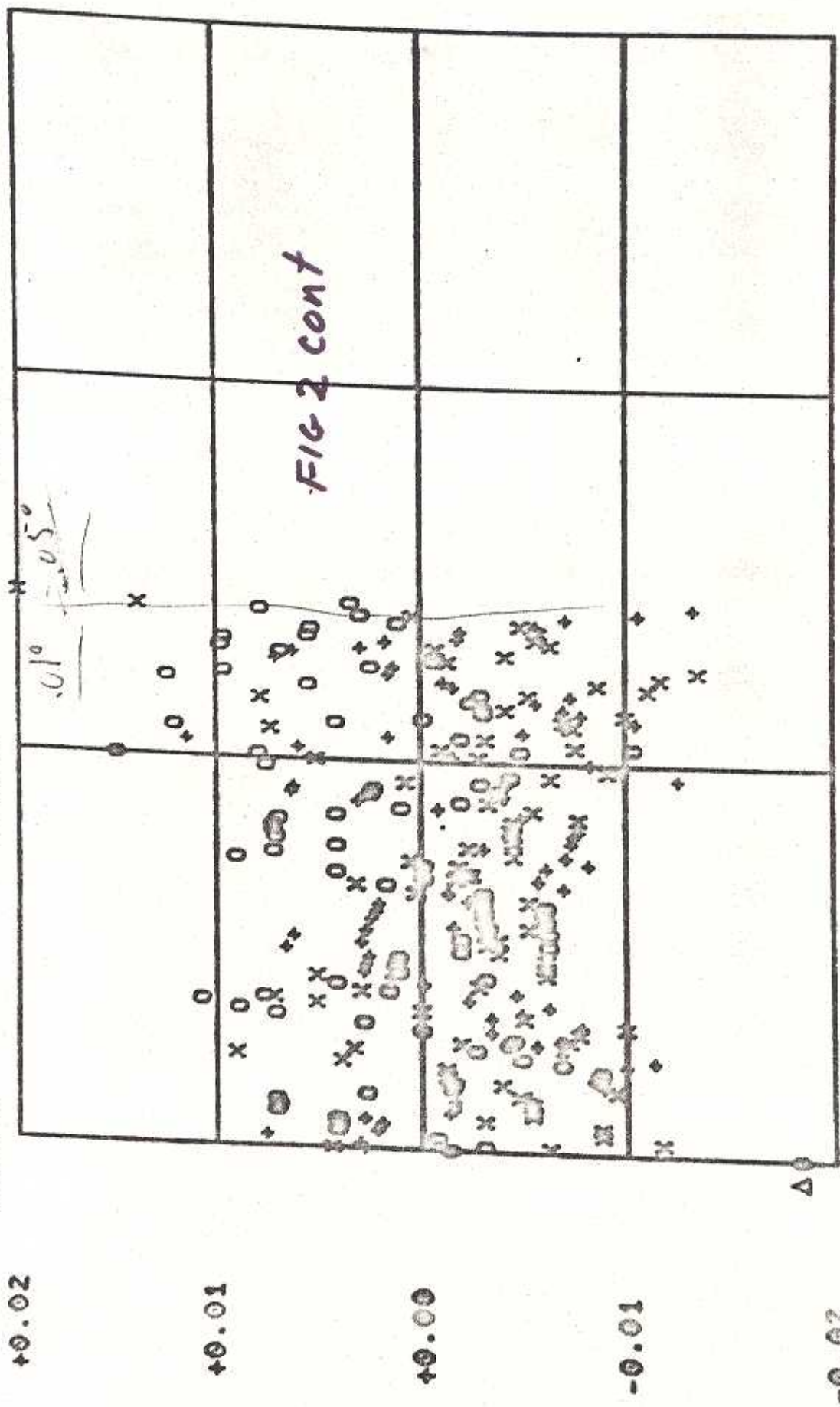
3.2.18

M40H0107J 31:23 OGMT= 87:22:03:21 GND= 88:00:18:34

SEC



F/V 3/102 GNC UP 2 P11842C  
 UPRATE SEC POINT 86 SITE BUC NOM=  
 R DAP ERRS P DAP ERRS Y DAP ERRS MED SCALE  
 V90H2143C =XL V90H2141C =OL V90H2142C =+L V72K8505X =AD  
 0.020 0.003 -0.013

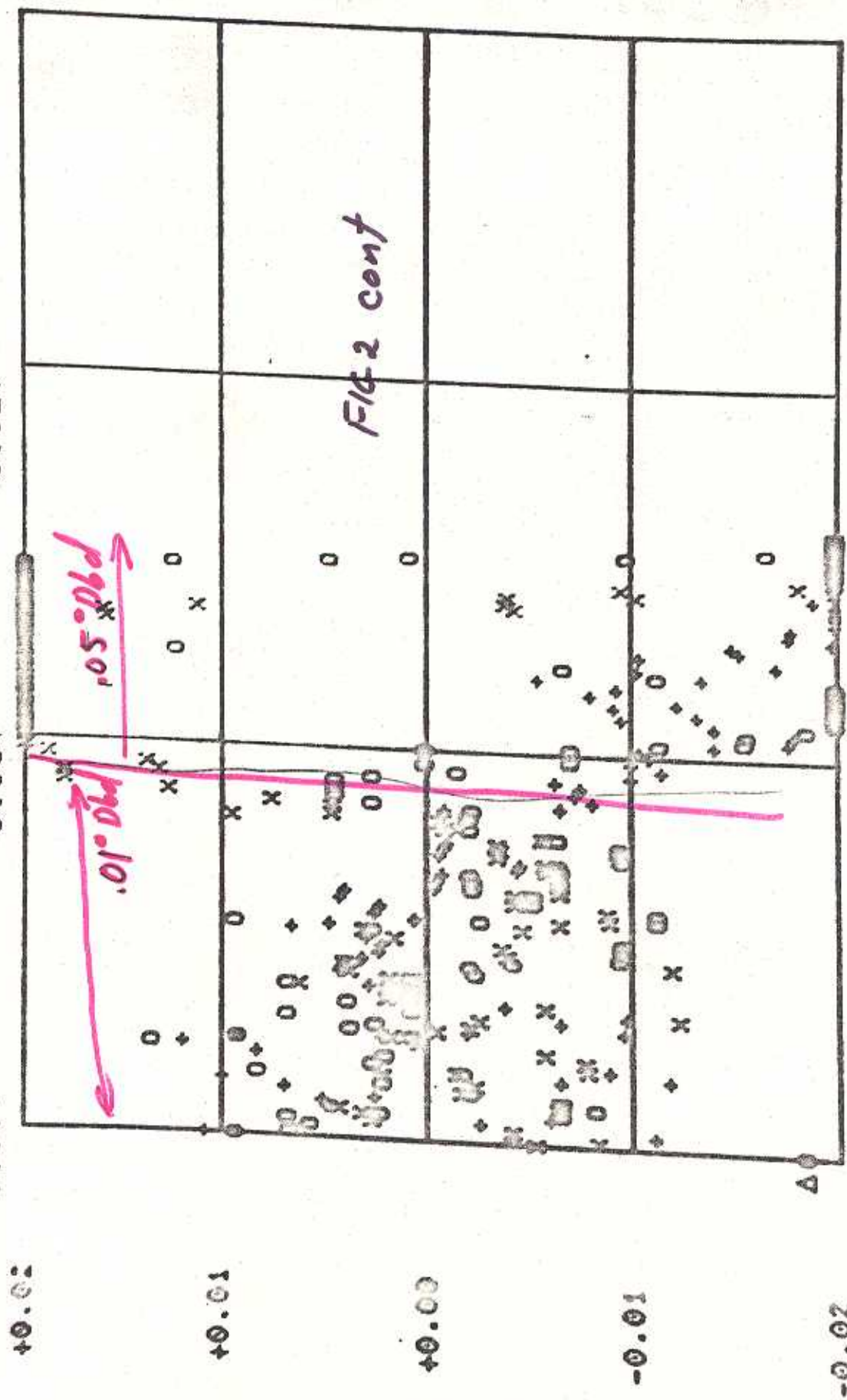


MAGN0107J 2:50 2 OGMT= 87:22:14:14 GND= 87:22:53:43 6

3.2.19

NAV N 9 7

EAV 3/102 GNC UP 2 P11842C  
 UDRATE SEC POINT 97 SITE BUC NOM=  
 R DAP ERRS P DAP ERRS Y DAP ERRS MED SCALE  
 V90H2103C =XL V90H2141C =DL V90H2142C =+L V72K505X =AD  
 -0.049 -0.039 -0.029



M40H0107J 3:12 0GNT= 87:22:18:31 GND= 87:22:59:00  
 0 2 4 6

3.2.20







FIGURE 3

LSD

L5L

F5R

F5L

R5R

R5D

1mm/sec

R5D Test

LSD  
Plume Imp Test

(4)

Plume  
impe

612  
70

3.2.22



220 Thermal Soakback Test (40mm/sec)

10 mV

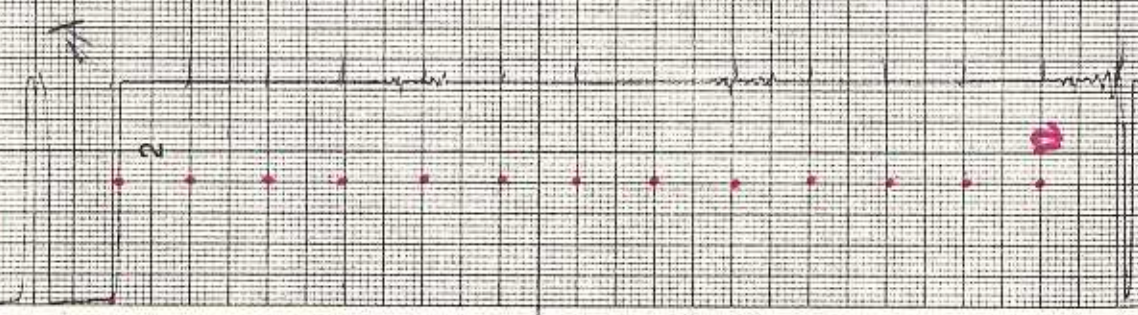
R1V



0  
5

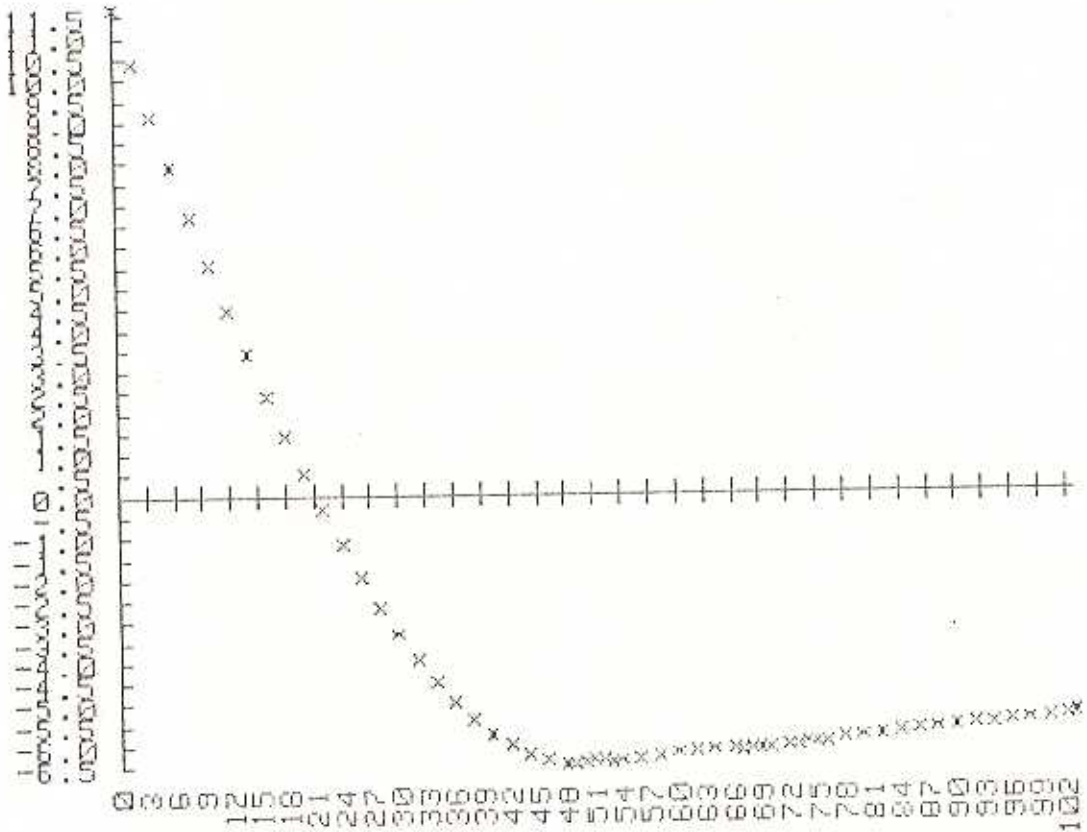
FIGURE 4

220





ROLL ERR



TIME - sec

FIGURE 5  
3.2.30



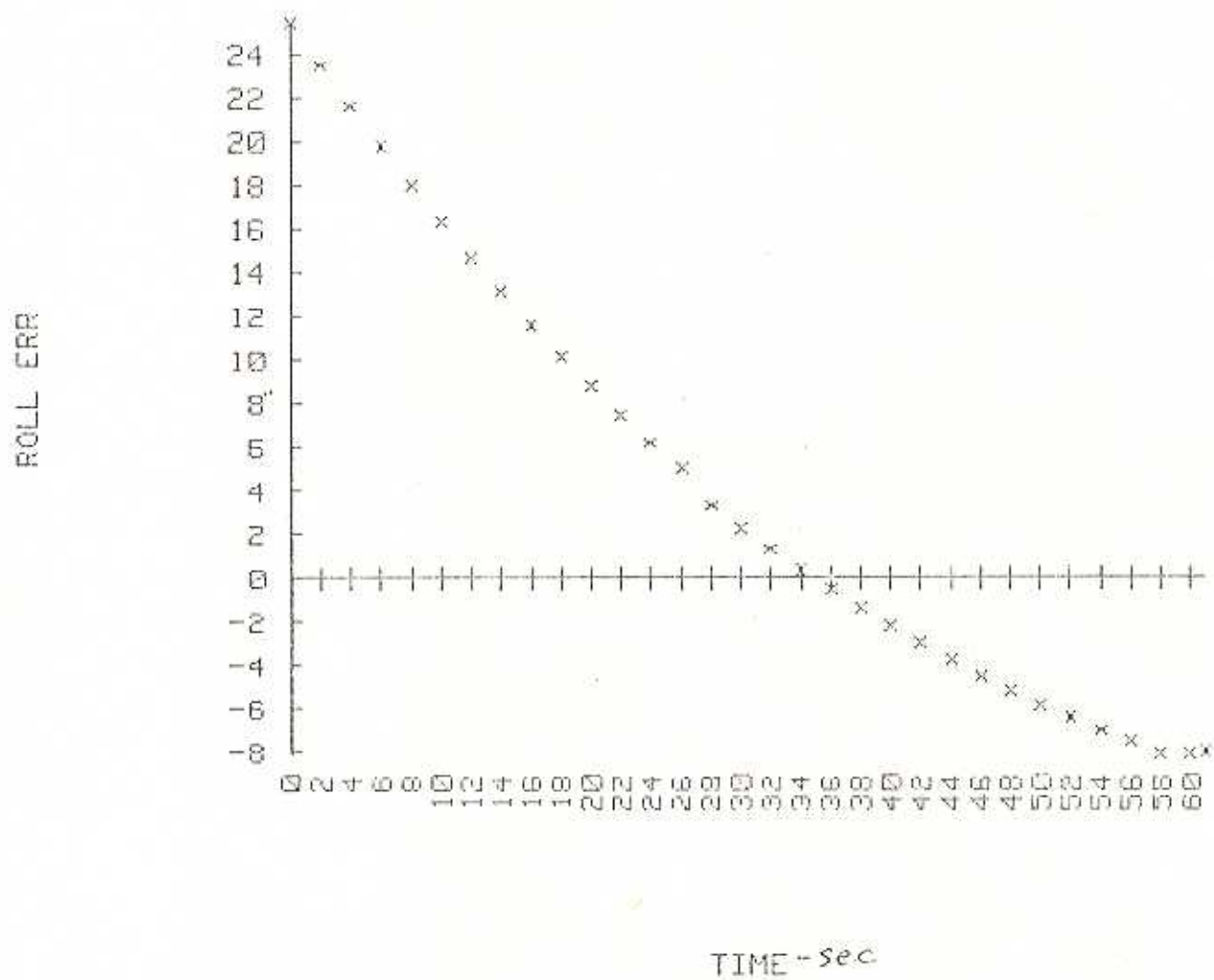


FIGURE 6 3.2.31





6

VEH ORG

AFT RNC

14040107J

ONBOARD CNT

	V72K 1248C ROLL1	V72K 1268C ROLL2	V72K 1288C ROLL3	V60H 2535C SEL1	V72K 1248C PITI	V72K 1268C PIT2	V72K 1288C PIT3	V60H 2535C SELP	V72K 1247C YAM1	V72K 1267C YAM2	V72K 1287C YAM3	V60H 2535C SELY
P 02:16:41:29.0	-0.2	-0.0	-0.2	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:30.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:31.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:32.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:33.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:34.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:35.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:36.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:37.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:38.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:39.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:40.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:41.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:42.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:43.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:44.0	-0.0	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:45.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:46.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:47.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:48.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:49.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:50.0	-0.2	24.3	27.2	27.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:51.0	55.8	70.3	70.8	70.8	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:52.0	70.5	75.1	72.0	71.8	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:53.0	42.7	0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:54.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:55.0	-0.0	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:56.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:57.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:58.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:41:59.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:00.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:01.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:02.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:03.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:04.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:05.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:06.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:07.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:08.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:09.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:10.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:11.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:12.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:13.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:14.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:15.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:16.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:17.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:18.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:19.0	-0.0	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:20.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:21.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2
P 02:16:42:22.0	-0.2	-0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.0	-0.2

+Roll and -Yaw  
(RHC)

FIGURE 8

RMS/PRCS Unloaded  
Test - Part I



R5D



R5R

)

L5D

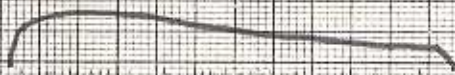
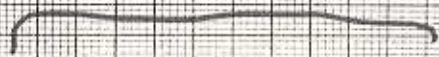


FIGURE 9

L5L



F5R

?

F5L

]



FSL

F5R

L5L

L5D

R5R

R5D

)

)

)

)

)

)

FIGURE 10



FSL

FSR

L5L

L5D

R5R

R5D

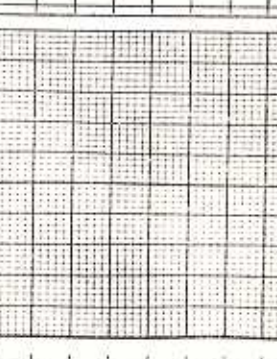
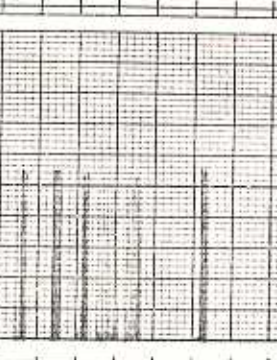
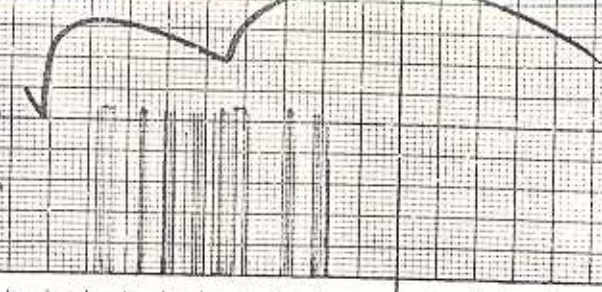


FIGURE 11

STS-3D



## TRANS DAP

### A. Performance

The Trans Dap for STS-3 was identical in design to the STS-2 system. Manual and auto maneuvers were executed with a nominal system response.

The first maneuver was in the manual accel mode, to the OMS 1 burn attitude. This is a time critical activity and cannot be performed in the auto mode which has a 0.2 °/sec maneuver rate. The CDR reached the burn attitude well before the burn time.

The second maneuver was in the auto mode, to the OMS 2 burn attitude. Everything looked nominal going to the attitude, however, an examination of the recorded dump data indicated that shortly after Madrid LOS, the crew downmoded to manual and completed the maneuver in the manual mode.

It was not obvious from the data if this was an inadvertent downmoding or intentional.

The transition to OPS 3 was executed with no problems. It appeared that the crew held the DAP manual PBI depressed during the transition since the data indicated the maneuver display, Item 27 was never set. No attitude deviations were noted after the transition. The auto maneuver to the De-Orbit burn ATT was nominal as was the De-Orbit burn.

The final auto maneuver to the entry interface attitude was interrupted when the CDR bumped the hot stick shortly after the maneuver began. The RHC was out of detent 0.2° for 1 computation cycle and downmoded the DAP to manual. This situation was apparently undetected for 4 to 5 minutes as both crewmen were monitoring LVLH attitudes on the ADI and with the vehicle in inertial hold, it appeared the spacecraft was pitching. After 4-5 minutes the auto maneuver was re-started with no further problems.

The OPS 1 and 3 OMS burns were nominal.

#### 1. Problem Analysis

The Hot Stick capability may cause a severe problem during some future mission. The crews need to be extra cautious on monitoring their DAP configuration when doing critical operations outside of site coverage.

#### 2. The STS-2 and STS-3 Data compared in an identical fashion.

### B. Lessons Learned - NONE

### C. Recommendations

1. LCC Limit changes - NONE
2. Flight Rule changes - NONE
3. SMS Parameter/Model changes - NONE
4. Console or MCC procedures changes - NONE
5. Data Retrieval Adequacy - improved over STS-2.



## ENTRY FLIGHT CONTROL

### A. PERFORMANCE

#### 1. Longitudinal Trim

After transition to MM304, the vehicle trimmed about the commanded 40 deg angle of attack with 4 long period oscillations ( $T \sim 25$  sec,  $|\alpha| = 2$  deg p-p) until the first roll command at  $\bar{q} = 15$  psf. The lowest and highest angle of attack, prior to the first roll, was 39.2 deg and 41.5 deg, respectively, and occurred in the first cycle.  $\delta\epsilon$  was +3 deg at MM304 transition and trimmed about the nominal schedule (+3 deg) with 4 long period oscillations ( $T \sim 23$  sec) corresponding to the  $\alpha$  oscillations. The maximum deflections from trim were 1.7 deg and 8.0 deg during the first cycle with  $\delta\epsilon$  converging toward schedule on each progressive cycle.

Post blackout,  $\delta\epsilon$  trim was +2.5 deg and closely tracked the nominal schedule until M4 where it reached maximum downward deflection (in supersonic region) of +4 deg. Only small body flap position changes (from 51% - 59%) were required to maintain  $\delta\epsilon$  on schedule. Small amplitude, high frequency oscillations ( $T \sim 1$  sec,  $|\delta\epsilon| \sim 0.4$  deg p-p) were seen while the speedbrake was sweeping to 100% at M10. There were no noticeable corresponding pitch rate oscillations. At M4, when the speedbrake began sweeping from 100% to 65%,  $\delta\epsilon$  began to trim upward off schedule and body flap began to drive from 62% to 0% (M3.5 - M1.7) to keep  $\delta\epsilon$  on schedule. Trim changes associated with the driving body flap are evident. Beginning at M3,  $\delta\epsilon$  followed schedule toward 0 deg at a small standoff error of approximately -0.5 deg. At M2.1,  $\delta\epsilon$  overshoot the 0 deg schedule and reached a maximum upward deflection of -2.5 deg at M1.75. Between M1.5 and M1.0,  $\delta\epsilon$  followed the schedule from 0 deg to +5 deg. All excursions from nominal schedule were within the predicted schedule presented in MPAD STS-3 Cycle 3 Descent Data Pack. Note that the body flap was saturated at 0% between M1.6 and M.95.

The M1 to M.90 region buffet which occurred on STS-1 and STS-2 was again evident on STS-3. The time histories of  $\delta\epsilon$ ,  $\dot{\theta}$ ,  $N_z$  and  $\alpha$  in this region are characteristic of previous flights with no unexpected vehicle responses. At M.92, the speedbrake was manually commanded to 100% for energy management and the resultant increase in pitching moment caused  $\delta\epsilon$  to trim to +10 deg at the end of the buffet region. In contrast, on STS-2, speedbrake was commanded to 57% at M.9 and  $\delta\epsilon$  trimmed to +7.5 deg at the end of buffet region. After buffet the body flap drove to 92% to force  $\delta\epsilon$  to maintain nominal schedule at +5 deg.

#### 2. Longitudinal Dynamics

After entry interface, prior to the first roll, the largest pitch rates occurred during the  $\alpha$  oscillations (-0.4 deg/sec and +0.24 deg/sec) and all were well damped. During the first roll, body pitch rates were between 0 deg/sec and -0.12 deg/sec. At M21.2 and  $\bar{q} = 37$  psf, a 1 cycle, 7 sec period pitch transient occurred with peak positive and negative pitch rates of 0.4 deg/sec and -0.7 deg/sec respectively. There were no residual oscillations associated with this transient.



Post blackout to the M2.7 roll reversal, body pitch rates were very steady about 0 deg/sec with maximum rates of  $\pm 0.2$  deg/sec occurring during roll reversals and during the speedbrake sweep from 0% to 100% at M10. The M2.7 reversal was flown in CSS. Control was good and maximum rate was -0.7 deg/sec.

In the transient region, the pitching phenomenon exhibited on STS-1&2 was again evident. A pitch down of -0.5 deg/sec occurred at M1.1 resulting in a decrease in  $\alpha$  from 9 deg to 6.5 deg causing the elevator to drive upward. At M.95 an abrupt pitch up of +0.9 deg/sec occurred increasing  $\alpha$  to 9 deg and driving  $\delta\epsilon$  down to +8 deg (speedbrake was manually commanded to 100% at this time driving  $\delta\epsilon$  further down to +10°). The body flap began to drive down to 92% to maintain  $\delta\epsilon$  on the +5 deg schedule.

Prior to the HAC, control was good (despite strong gusty winds) with the CDR inputting small pitch down commands less than -5°. Body pitch rates were between 0 deg/sec and -0.9 deg/sec and exhibited oscillations consistent with winds and gusts. Airspeed was 220 KEAS and increased to 290 KEAS at the initial roll into the HAC. A right turn HAC was flown in manual with only the body flap in auto.

In all cases the vehicle dynamic response to automatic and manual longitudinal commands was satisfactory.

### 3. Lateral Directional Trim

Throughout the entry prior to rudder activation, the aileron trim averaged .5 deg to .6 deg. The constant value of this trim implied a lateral CG displacement in excess of the predicted value of -.07 inches at EI. The supposition that the lateral asymmetry was due to a YCG offset rather than aerodynamic phenomena is reinforced by the .75 inch uncertainty in YCG at the preflight weighing at KSC. The trim required indicates a YCG offset between .7 inches and 1 inch.

Following rudder activation at M3.5 the aileron trim became negligible and the rudder trimmed the asymmetry. The maximum average rudder trim was 1.5 deg and occurred subsonic prior to HAC intercept. There were no significant or adverse effects due to the trim solution for STS-3 and the flight control system performed satisfactory in this regard.

### 4. Lateral Directional Dynamics

The dynamic response of the vehicle to flight control commands was evaluated by observing the transients associated with PTI's and Roll Reversals. In all cases the commanded rates were achieved within two seconds and no residual oscillations were observed. During transition to Constant Drag Phase the transient due to the phase change resulted in a 10 degree bank angle change instead of the 15 degrees predicted. No other moding or phasing transients were observed during the entry in the lateral directional axes.

The .25 Hz oscillation occurred as expected beginning at M1.8 and ending about M1.5. The oscillation lasted about 30 seconds and produced peak lateral accelerations of .01g. Peak roll rates reached 1 deg/sec before a yaw jet fired to arrest the rate. There is little doubt that the RCS jets were the principal effectors in constraining the oscillation.



## 5. Autoland

Initial conditions prior to selection of auto flight control: the CDR followed guidance speedbrake commands and retracted the speedbrake from 100% to 17% as equivalent airspeed decreased from 290 KEAS to 265 KEAS. Airspeed began to increase, due to increasing  $\dot{h}$ , and the CDR modulated  $\delta_{SB}$  according to guidance commands. The MLS was incorporated into navigation at 14700 feet altitude while the vehicle was in a 3 cycle pitch oscillation,  $T \approx 3.5$  sec and maximum positive and negative body rates of +2.6 deg/sec and -2.0 deg/sec, respectively.  $\delta_{\epsilon}$  responded well to the RHC commands and was driven off the +5° trim schedule to +2.5°. During the oscillations,  $\dot{h}$  increased from -191 fps to -224 fps causing the vehicle to drop below the  $h_{ref}$  vs. range trajectory commanded by TAEM guidance. CDR followed guidance and commanded pitch up to decrease  $\dot{h}$  and capture the trajectory pulling 1.4g at a body pitch rate of 1.9 deg/sec. The RHC was returned to detent prior to engaging auto and pitch rate decreased to 0.6°/s.

Auto P/R/Y was selected at 089:16:03:21 onboard GMT (all subsequent times will specify minutes and seconds only) at  $h=11600$  feet, still below trajectory, and immediately commanded pitch up to 1.5g ( $\Delta N_{zc}=+0.5g$ ) at 2.2 deg/sec. At :03:23 and  $h=11200$  feet, auto speedbrake was selected and immediately opened to 49% to hold airspeed to the reference velocity of 285 KEAS. After the peak normal acceleration of 1.5g was attained (:03:26)  $N_{zc}$  changed sign and commanded pitch down ( $\Delta N_{zc}=-0.24g$ ) resulting in a pitch rate of -0.8 deg/sec,  $N_z=0.8g$  and the

start of a phugoid oscillation as seen in STS-2 when auto pitch was first selected while in TAEM prefinal subphase. Concurrent with the phugoid, TAEM roll/yaw guidance commanded a roll angle,  $\phi_c=27$  deg (from  $\phi=25$  deg) then  $\phi_c=18$  deg taking the vehicle through body roll rates of 6.0 deg/sec:

and -10 deg/sec, bringing course with respect to runway centerline to +5 deg and reducing crossrange to -203 feet. After .75 cycle of the 12 sec phugoid was completed (:03:30) the altitude error criteria for transition to autoland guidance was satisfied and the transition to trajectory capture subphase of approach/landing occurred at  $h=10094$  feet (by :03:25 the criteria for flight path angle, crossrange and dynamic pressure had all been satisfied leaving altitude as the only unsatisfied requirement).

On the first pass after transition, the body flap was commanded and drove to trail position and the speedbrake was commanded to its reference of 55 deg and modulated about that reference to maintain 285 KEAS. Autoland longitudinal guidance was satisfied with  $h$  vs. range and reduced  $N_{zc}$  to 0.03g at :03:31 which resulted in a pitch up of 1.1 deg/sec. Criteria of  $|\phi_{err}| < 2$  deg and  $|h_{err}| < 50$  feet for transition to steep glideslope subphase was satisfied at :03:33,  $h=9516$  feet and guidance made that transition. Transition to lateral track mode was at :03:35 when criteria of course with respect to runway centerline  $< 2$  deg and crossrange  $< 50$  feet were satisfied. From transition until CSS was engaged, roll oscillations occurred (max positive and negative rates, 5.0 deg/sec and -3.2 deg/sec respectively) due to strong crosswinds and gusts while trying to track the centerline. Wind velocity increased while on steep glideslope causing the vehicle airspeed to increase to 296 KEAS at :03:54. The speedbrake extended to 98% at :03:55,  $h=5208$  feet causing  $\delta_{\epsilon}$  to trim down to +8 deg. Subsequently, vehicle airspeed decreased and guidance commanded the speedbrake to retract to less than 55 deg such that, at :04:02,



the first autoland speedbrake retract criteria had been satisfied and speedbrake was commanded to 0°.  $\delta E$  trimmed upward to +4 deg as the speedbrake retracted and max positive and negative body pitch rates of +1.3 deg/sec and -1.1 deg/sec respectively were reached. Direct airspeed control was lost with the speedbrake closed until touchdown resulting in increased airspeed.

Longitudinal guidance transitioned to flare and shallow glideslope subphase at :04:15 as the vehicle descended below 2000 feet. The open-loop pullup initiation subfunction commanded  $\Delta N_{zc}=0.2g$  and vehicle pitched up at 2.1 deg/sec. At :04:17, vehicle descended below 1700 feet and guidance transitioned to circularization subfunction where it commanded a constant 1.4g circle ( $\Delta N_{zc}=+0.4g$ ) and pitch rate of +1.4 deg/sec. This pullup arrested the increasing airspeed at 303 KEAS and reduced it to 290 KEAS. At :04:25, h=600 feet, the guidance command decreased to  $\Delta N_{zc}=0.23g$  reducing the constant g circle from 1.4g to 1.2g causing body pitch rate to oscillate to -0.1 deg/sec then 1.0 deg/sec (in effect, "letting out" the constant g circle). This maneuver was analyzed and it was determined that an upward gust or shear caused vehicle  $\dot{h}$  to decrease such that the altitude rate error component of the  $N_{zc}$  commanded a reduced g circle. At :04:31, h=200 feet, the vehicle passed -4723 feet downrange (X\_EXP I-load) causing guidance to transition to exponential capture subfunction.  $N_{zc}$  was reduced to  $\Delta N_{zc}=0.11g$  and body pitch rate went to 0 deg/sec. The CDR selected CSS via the PBIs at :04:33.

Autoland performance was good and no anomalies were seen. The vehicle maintained reference altitude versus downrange position from steep glideslide transition until CSS and tracked the runway centerline at 0.4 feet  $\pm$  10 feet from h=2038 feet until CSS.

## 6. Landing/Rollout

The only flight control system inadequacy observed on STS-3 occurred during rollout when the CDR attempted to arrest a nose down pitch rate of 1 deg/sec. Three seconds following main gear touchdown the CDR initiated a nose down 1 deg/sec pitch rate with a forward RHC input. As the nose started falling through from its touchdown attitude of 6 degrees the CDR input approximately 5 degrees aft stick to arrest the nose down rate. Although the elerons ramped up in response to the stick input they were unable to arrest the rate. Finally as pitch attitude approached 0 degrees the CDR increased the magnitude of the aft stick input to approximately 12 degrees. Response to this input was characterized by considerable lag time (2 to 3 seconds) requiring excessive pilot compensation to control pitch attitude. Once the pitch rate error signal became large enough however the elevons were powerful enough to control pitch. Airspeed during this portion of the rollout decreased from 200 KEAS to 175 KEAS.

The problem with vehicle control during the rollout appeared to be related to the rather delicate balance of two very large pitching moments. Following main gear touchdown the weight of the vehicle causes a large nose down pitching moment about the main gear. Early in the rollout this weight moment is balanced by the positive pitch moment created by the lift force. As the rollout speed diminishes and angle of attack decreases, the weight moment overtakes the aerodynamic moment, and the imbalance must be accommodated by an elevator deflection from trim.



inputs Elevator control power is also decreasing however as a function of rollout speed and a reduced moment arm. Unless control inputs require the elevons to ramp fast enough to get ahead of this dynamically changing moment balance they will be ineffective in controlling the rate.

The response characteristics of the vehicle during landing rollout are not satisfactory to permit active pilot control of pitch rate.

## 7. Entry Test Manuevers

The STS-3 entry had six lateral directional PTIs (Programmed Test Input), one pitch ASI (Aerodynamic Stick Input) and one structural PTI planned. Figure 1 is a layout of STS-3 entry maneuvers including bank reversals. It shows the maneuvers, planned and actual flight conditions, and time of occurrence. All bank maneuvers occurred on schedule for the Northrup-Rev. 129 entry and all 5 test maneuvers, above Mach 10, were executed on time with predicted responses. The Mach 8.4 maneuver was executed on time, however, the yaw PTI-2 was performed in place of the roll PTI-1. This PTI-2 was performed safely but with resulting motion somewhat larger than would be expected. It was not the optimum maneuver at that point but useful data can be extracted.

The Mach 4.5 to 4.0 PTI-2 was eliminated from the flight plan pre-entry because of the expected conflict with the third bank reversal. This conflict did occur, although the reversal was completed 11 seconds before the close of the window at mach 4.0. The structural PTI-0 was executed on time and ran the full time period planned. The data from PTI-0, however, was lost because of a failure of the wide-band mission recorder.

## 8. Entry RCS Usage

The STS-3 entry AFT RCS usage was very close to the predicted usage. Figure 2 shows the usage during several selected time periods and figure 3 shows a graphical comparison of predicted vs actual usage on both STS-2 & 3.

The two solid lines in figure 3 represent the predicted entry usage from EI to Mach 1. The STS-2 prediction was a nominal FSL (STS-1 Aero) entry with maneuvers. The STS-3 prediction was based on actual STS-1 entry data adding in (FSL, SPS, AFFTC) simulator estimated usage for individual test maneuvers. The STS-3 prediction, adjusted for the deleted PTI, matched the actual usage fairly well, especially below Mach 18 with the total usage off by only 6 lbs.

If the predicted maneuver usage of STS-2 & 3 is subtracted from the flight data and compared with STS-1 the total usage for all three entries (with no maneuvers) compares within a hundred pounds. This comparison shows a high degree of repeatability given that the first 3 flights used the same entry alpha profile but with different elevator schedules and significantly different winds & turbulence conditions.



## B. LESSONS LEARNED

1. In cases where high tailwinds and large left HAC turns are concerned, the right HAC turn procedure used on this flight is a good alternative.
2. Moding the speedbrake to manual and 100% at M.9 to control airspeed during short HAC turns with a strong tailwind is a simple and effective way to prevent a transient airspeed surge and facilitate chase intercept.
3. Significant uncertainty still exists as to Y CG location.
4. The .25Hz oscillation is a recurring phenomenon between M1 and M2.5, and at present appears to be easily constrained by the RCS jets.
5. The autoland speedbrake retract logic was designed to accomodate the mean wind profiles of EDW/KSC. The wind shear encountered on the NTP landing tricked the speedbrake into closing early. At present no plans exist to change the logic.
6. The flight control system is unable to provide satisfactory closed loop CSS pitch rate response after main gear touchdown.
7. While the execution of PTI-2 in place of PTI-2 at M8.4 was not harmful; had it occurred at M2 instead of PTI-0, it might have violated the vehicle lateral load limits. More care must be exercised by crew and by the aero flight controllers to insure that the correct maneuver is selected.
8. Although the M4.0-4.5 PTI conflicted with the 3rd Roll Reversal, 11 seconds remained after completion of the reversal during which the PTI could have been executed. Perhaps outright elimination of this maneuver preentry was a bit hasty.
9. The excellent track record of RCS fuel usage predictions were again reinforced on STS-3. The increased confidence on our ability to predict RCS fuel requirements supports a recommendation for a reduced RCS redline for STS-4.

## C. RECOMMENDATIONS

1. Right HAC turns should be considered whenever the left HAC turning angle exceeds 270 deg and the tailwind component at intercept exceeds 80 kts.
2. A stability analysis of the .25 Hz oscillation should be conducted to evaluate damping techniques or useful downmodes for a no RCS case.
3. A study should be conducted to determine the feasibility of improving the vehicle pitch control response after main gear touchdown.
4. If it is not feasible to improve post touchdown handling qualities it is recommended that the crew training be assessed to determine if additional time needs to be spent in this area.



5. The no yaw jet redline for STS-4 should be reduced from 600 lbs to 400 lbs, and the "terminate maneuver line" should be reduced from 1700 lbs to 1200 lbs at EI.
6. The number and scheduling of entry maneuvers should remain as planned for STS-4 with no significant increase in the number until the automated PTI module is available for use.

3.4.7

3.4.7



STS-3  
ENTRY MANEUVERS

MANEUVER	FLIGHT CONDITION			GMT	REMARKS
	CUE CARD	NOR/REV. 129 DELTAS	STS-3 ACTUAL		
FIRST BANK (CSS, roll at 3%)	CSS $\bar{q} = 10$	—	CMD $\bar{q} = 14.2$ CSS ROLL $\bar{q} = 15.2$ COMPLETE $\bar{q} = 17.6$	15:39:58 40:105 40:30	MAX. $\dot{\phi} = 2.96\%/sec$ CSS
PTI-1	$\bar{q} = 22$	—	EXEC $\bar{q} = 22.9$	41:56	
PTI-1	V = 21,500 -20,500	—	EXEC V = 21,370	45:36	
PITCH ASI			START V = 21,212	45:48	
PTI-1	V = 18,000 -17,000	V = 19,000 -16,000	EXEC V = 18,724	48:25	
FIRST BANK REVERSAL	V = 14,800	V = 17,700	CMD V = 17,783 COMP. V = 16,930	49:09 49:44	AUTO
PTI-1	V = 14,000 -12,000	—	EXEC V = 12,590	52:05	
SEC. BANK REVERSAL	V = 10,000	V = 9,300	CMD V = 9,370 COMP. V = 8,550	53:45 54:14	AUTO
PTI-1	V = 8,400	—	EXEC V = 8,360	54:21	PLANNED PTI-1 ACTUAL PTI-2
THIRD BANK REVERSAL	V = 5,000	V = 4,500	CMD V = 4,710 COMP. V = 4,210	56:57 57:22	AUTO
PTI-2	M = 4.5-4.0	ELIMINATE	—	—	CONFLICT WITH 3rd BANK REV.
FOURTH BANK REVERSAL	M = 2.6	—	CMD M = 2.56 CSS ROLL M = 2.56 COMP. M = 2.42	58:54 58:54 59:10	CSS
PTI-0	M = 2.2 -0.9	—	EXEC M = 2.10 INHIBIT M = 0.88	59:23 16:01:29	STRUCTURAL PTI

FIGURE 1

3.4.8



STS-3  
ENTRY RCS USAGE

ENTRY PERIOD	GMT	LEFT (Lbs)	RIGHT (Lbs)	TOTAL AFT (Lbs)
D/O TIG to EI	15:13:28-15:34:43	82	81	163
D/O TIG to MACH 1	15:13:28-16:01:00	659	671	1330
EI-5 to EI	15:29:43-15:34:43	49	49	98
EI to MACH 1	15:34:43-16:01:00	577	590	1167
EI to MACH 7	15:34:43-15:55:15	475	484	959
MACH 7 to MACH 1	15:55:15-16:01:00	102	106	208

STS-3 PREDICTION  $\neq$  EI to MACH 1 = 1234 - 61 (Deleted PTI)  
 (STS-182 FLT. DATA PLUS FSL, SPS & AFFTC DATA)  
 = 1173 Lbs

STS-3 ACTUAL  $\neq$  EI to MACH 1 = 1167 Lbs

FIGURE 2

3.4.9

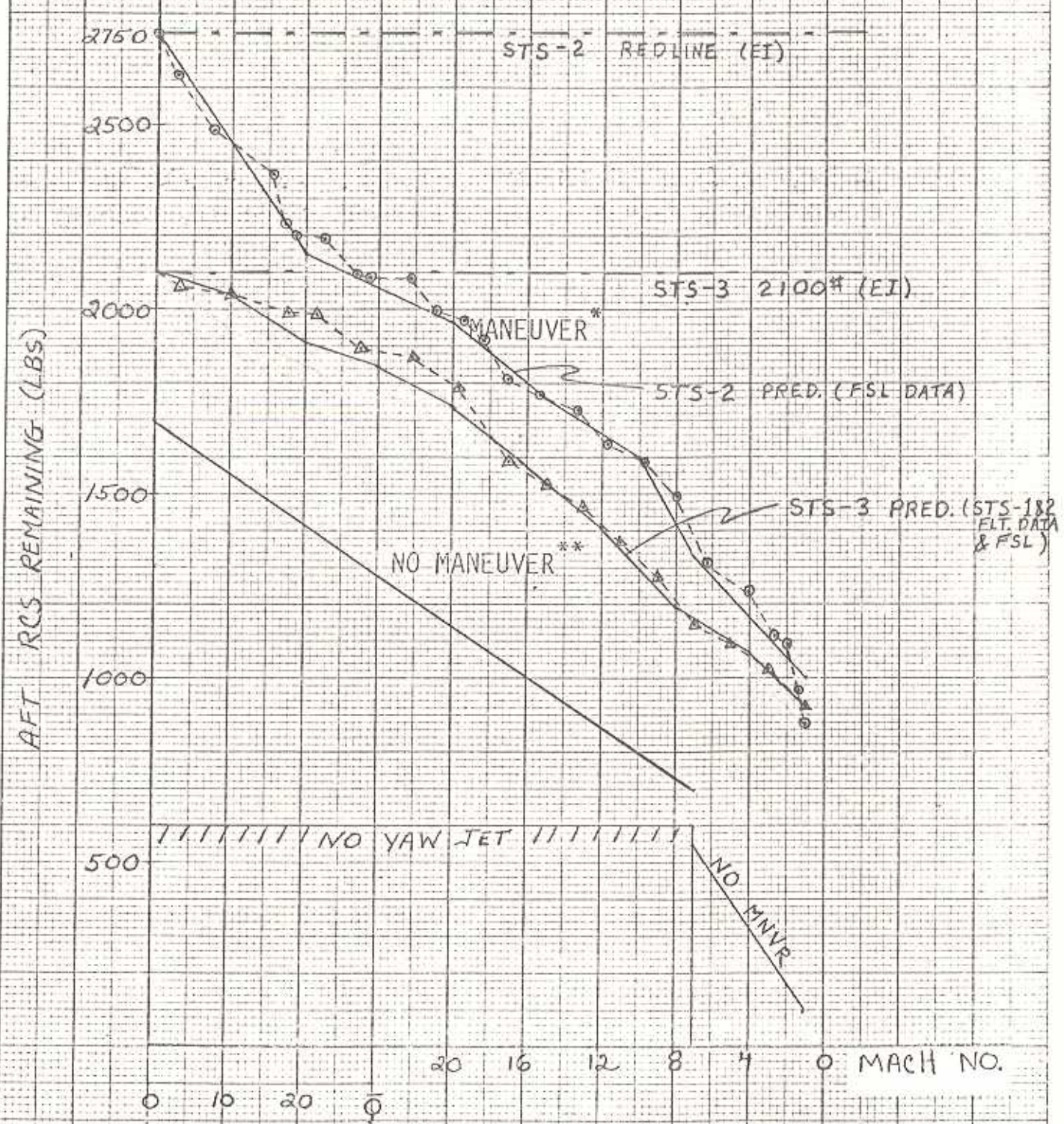


8/19/81 Jsh  
 1/14/82 RW  
 4/9/82 RW

# STS-2 RCS USAGE

& STS-3  
 (ENTRY AFT RCS EI to Mach 1)

○--○ STS-2 ACTUAL  
 BIASED TO REDLINE  
 ▲--▲ STS-3 ACTUAL  
 BIASED TO REDLINE



\* AVG SIDE USAGE  
 \*\* STS-1 USAGE + PAD

FIGURE 3

BEE 20x20 TO INCH



## GRAVITY GRADIENT

### A. Performance

The STS-3 gravity gradient (gg) test was scheduled for a 2 hour - 40 minute period beginning at 7 hours MET. The gg test was initiated at 81:23:29:30 GMT (07:29:30 MET) and completed at 82:01:19:00 GMT providing an actual test period of 1 hour - 50 minutes. The orbiter nose was pointed toward the center of the earth for the gg test; the universal pointing body vector load was  $P=356.3^\circ$ ,  $Y=2.6^\circ$  and  $OM=235.5^\circ$ . The tracking maneuver to establish the test gg attitude was accomplished with vernier jets utilizing an attitude deadband of  $1.0^\circ$ , rate deadband of  $0.02^\circ/s$  and DAP rate of  $0.4^\circ/s$ .

Gravity gradient was initiated by DAP manual selection very close to the desired target conditions as shown in Table I and Figures 1-9. The pitch (P) and yaw (Y) attitude errors from the target values were  $0.4^\circ$  and  $0.8^\circ$  respectively; roll (R) attitude and the R, P, and Y rates were essentially on target. The vehicle gg oscillation slowly diverged during the test period achieving maximum attitude deviations of  $\sim 13^\circ$  in roll and  $\sim 2^\circ$  in pitch and yaw. The period of oscillation was 80 minutes, approximately equal to the time for one orbit; consequently only slightly more than one oscillatory cycle was observed. It is not obvious from the data that the oscillation would stop diverging and reach a steady state equilibrium condition though this would be expected to occur. Pitch and yaw rates oscillated about their respective orbit rate component, slowly diverging, driven primarily by the roll excursions. The roll attitude error was diverging as shown by each succeeding peak doubling in amplitude. The roll error oscillatory trend suggests that the equilibrium or mean value was biased 4.5 degrees from the original  $237.5^\circ$  value. The true roll equilibrium attitude is determined by locating the roll attitude error inflection point which occurs at the maximum roll rate condition as shown in Figure 10. This solution indicates the actual equilibrium roll attitude should be  $233^\circ$ , not the initial  $237.5^\circ$  condition. The initial pitch and yaw attitudes appear to be satisfactory. Since roll excursions significantly influence the pitch and yaw results, reduction in the roll oscillation is necessary in order to more effectively evaluate pitch and yaw activity. If the gg test were reinitiated at the revised attitudes and these were in fact the true equilibrium values, attitude deviations of less than  $1^\circ$  in all axes could be expected. The STS-3 gg test period was not of sufficient length to fully evaluate the gg performance since steady state conditions were not achieved nor revised targets utilized. It appears that a minimum of two cycles or orbits are necessary in order to even begin to adequately evaluate gravity gradient.



## GROUND EVALUATION PROCEDURES

The following is a discussion of the procedures utilized to acquire and plot the gg data for analysis. The data required for gg evaluation are the universal pointing total attitude errors (eigen quaternion), ADI rates, and LVLH attitudes (euler angles) for roll, pitch, and yaw together with onboard GMT. This data was put on a universal digital display (see encl 1) and a hardcopy made in one minute intervals during real time passes and playbacks. Initially, the ten parameters were hand recorded at four minute intervals as a backup to the hardcopy data. It required approximately 45 seconds for one person to copy the ten parameter values. Thrift data was obtained for one region for which playback was not available as noted in Figures 10-12. However, the thrift rate data was printed out to two decimal places which was not sufficient; four decimal places is required for the analysis of pitch, yaw and roll rates. The thrift decimal accuracy for LVLH and error attitude was adequate (See encl 2).

A HP9845 computer and a regression curve plotting program were utilized to obtain the data plots shown in figures 1 through 9 for evaluation of gravity gradient performance. The values for the ten parameters, in four minute intervals, were stored in the plot program following each realtime pass and playback period. The data was then plotted and a curve fit made. The program has no specific intelligence pertaining to gg, it works with any data and performs a best fit solution. Using the HP9845 consumed considerable time, entering and storing data and repeatedly developing the plots each time new points were added. Use of the HP9845 and the associated time expended does not seem warranted, since there are sufficient number of data points and the data scatter is minimal. Hand plots will do the job adequately and quicker. Consequently, the hand plots shown in figures 10 through 12 are recommended for use, successively plotting the data as it is acquired. Total attitude errors and rates are the primary evaluation parameters, while LVLH is secondary. The axes motions should be evaluated, in their order of significance, beginning with the least stable: roll, yaw, and pitch. Roll motion is a major factor impacting pitch and yaw activity. The four minute data sample interval is sufficient for plotting and analysis. Hardcopies each minute is conservative, but provides additional data should some disturbance occur and generate a more dynamic situation.

The above procedure is dependent on getting playbacks and having a working hardcopy. Thrift with an increased rate decimal accuracy or a delog of the universal digital display in one minute intervals are alternatives if either playback or hardcopy are not available. An alternative for a hardcopy failure is to hand copy the data.

### B. LESSONS LEARNED

1. Use of the HP9845 and the regression curve fit program were not necessary for plotting gg curves. Hand plotted curves are adequate and can be produced more quickly.
2. Thrift rate data decimal accuracy was not sufficient for gravity gradient analysis.
3. One orbit of gravity gradient operation did not provide a sufficient number of cycles or time period for adequate analysis.



### C. RECOMMENDATIONS

1. Have crew note and pass to ground gravity gradient start and stop GMT in order to expedite playback data gathering.
2. Handplot gravity gradient data as it is acquired on graph axes scaled prior to the mission to reflect expected oscillation amplitudes and limits.
3. Increase decimal accuracy of thrift rate data to four places to provide adequate analysis.
4. For test and evaluation, conduct gravity gradient operations for a minimum of two cycles or orbit to permit any gg oscillation to approach its equilibrium condition and permit reasonable prediction of any revised alternative initial equilibrium attitudes.
5. Document Orbit GNC display during tracking maneuver just prior to initiating gg to determine deviations from target initial conditions.
6. Set up three Universal Plots one each for roll, pitch and yaw showing total error and rate vs time together on the same plot. Suggest a plot rate of 60 sec/pt with a time scale of 0-90 minutes; total error and rate scales would be the same as those in #2 above.
7. For the STS-4 gravity test establish reasonable P, R and Y oscillation amplitudes which could be expected and conditions which if encountered or limits which if exceeded would require action to be taken. Define alternative actions and the analysis required to support a particular course of action.
8. Define the STS-4 real time tasks of GNC, FAO, and E&D in terms of their relative responsibilities for data acquisition and presentation, gravity gradient performance evaluation and conclusions, specification of actions to be taken, and making of calls.
9. Identify factors which influence gravity gradient performance such as mass properties, crew activity, venting, sun spot activity (air density), orbit geometry, etc., determine if it is necessary to track them during the mission and establish appropriate procedures and interfaces as required.



TABLE I

A. UNIVERSAL POINTING INFO				
BODY VECTOR	TARGET	TRKG RATE	DAP CONF	
P 356.3°	Center	P +0.036°/s	ATT DB 1°	
Y 2.6°	of	Y -0.057°/s	Rate DB 0.02°/s	
R 237.5°	Earth	R +0.002°/s	DAP RATE 0.4°/s	

B. CONDITIONS AT GG INITIATE				
TARGET LVLH ATTITUDE	ADI LVLH <sup>1</sup> ATTITUDE	$\Delta$ ATTITUDE	TOTAL ERROR <sup>2</sup>	ADI RATE
P 265.84°	266.20°	+0.36°	-0.436°	+0.0366°/s
Y 358.24°	357.45°	-0.79°	-0.858°	-0.0581°/s
R 237.44°	237.63°	+0.19°	-0.083°	-0.0002°/s

NOTES: 1 LVLH based on euler angle  
 2 Total error from universal pointing based on elgen quaternion.



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UNIVERSAL DIGITALS 3 RT1023B

41	V95H7490C	R	TOT	ERR	2.75100	
42	V95H7491C	P	TOT	ERR	-0.74177	
43	V95H7492C	Y	TOT	ERR	0.31412	
44						
45	V72R0916C	R	ADI	RATE	0.00220	
46	V72R0917C	P	ADI	RATE	0.03932	
47	V72R0918C	Y	ADI	RATE	-0.05543	
48						
49	M01E0200C	R	L	ADI	ATT	234.74374
50	M02E0200C	P	L	ADI	ATT	265.07541
51	M03E0200C	Y	L	ADI	ATT	357.83799
52						
53	M04E0200C	R	R	ADI	ATT	234.75182
54	M05E0200C	P	R	ADI	ATT	265.03359
55	M06E0200C	Y	R	ADI	ATT	357.85199
56						
57	M40H0107J	GMT			81:23:46:33	
58	M40H0121J	NET			8:07:46:33	
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IMU RM ATT TH 0.0000042013

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3.5.5

ENCL 1

000 100 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100



*Calvin*

**THRIFT**

0	01:20:32:14.0	0-0005	187.205	269.405	84.405	17.055	751.995	89.055	0.945	0.775	0.085
P	01:20:32:14.0	0-0005	187.205	269.405	84.405	17.055	751.995	89.055	0.945	0.775	0.085
P	01:20:33:44.0	0-0000	180.000	267.000	84.400	244.111	251.995	85.005	0.380	-0.480	-0.810
P	01:20:35:43.0	0-0000	180.000	187.200	84.400	291.720	251.995	85.005	0.670	-0.490	0.550
P	01:23:28:58.0	356.300	237.500	259.100	299.900	29.395	194.004	335.633	-0.255	-0.420	-0.820
P	01:23:28:58.0	356.300	237.500	210.100	299.900	31.160	157.977	333.669	-0.030	-0.440	-0.840
P	01:23:30:57.0	356.300	237.500	210.100	299.900	33.210	162.117	333.693	0.180	-0.470	-0.750
P	01:23:31:57.0	356.300	237.500	210.100	299.900	35.360	166.360	330.395	0.390	-0.500	-0.680
P	01:23:33:51.0	356.300	237.500	210.100	299.900	38.689	174.700	327.716	0.800	-0.550	-0.550
P	01:23:34:53.0	356.300	237.500	210.100	299.900	42.666	179.570	326.577	1.070	-0.580	-0.480
P	01:23:36:40.0	356.300	237.500	210.100	299.900	48.070	188.770	324.933	1.448	-0.610	-0.330
P	01:23:37:49.0	356.300	237.500	210.100	299.900	51.110	193.773	324.360	1.666	-0.620	-0.250
P	01:23:39:48.0	356.300	237.500	210.100	299.900	57.113	203.998	323.889	2.044	-0.640	-0.100
P	01:23:41:47.0	356.300	237.500	210.100	299.900	63.019	213.220	324.255	2.395	0.666	0.000
P	02:00:25:59.0	356.300	237.500	210.100	299.900	92.982	31.500	39.333	-5.250	0.230	-2.200
P	02:00:26:59.0	356.300	237.500	210.100	299.900	99.800	36.620	38.900	-5.260	0.340	-2.200
P	02:00:27:59.0	356.300	237.500	210.100	299.900	46.770	41.688	38.260	-5.230	0.440	-2.200
P	02:00:28:59.0	356.300	237.500	210.100	299.900	43.885	46.610	37.440	-5.170	0.520	-2.110
P	02:00:29:59.0	356.300	237.500	210.100	299.900	40.988	51.590	36.330	-5.060	0.620	-2.110
P	02:00:30:59.0	356.300	237.500	210.100	299.900	38.306	56.270	35.110	-4.920	0.680	-2.100
P	02:00:32:59.0	356.300	237.500	210.100	299.900	33.633	65.620	32.117	-4.630	0.830	-2.010
P	02:00:33:59.0	356.300	237.500	210.100	299.900	31.594	69.444	30.448	-4.280	0.880	-1.894
P	02:00:34:59.0	356.300	237.500	210.100	299.900	29.653	73.594	28.670	-4.000	0.910	-1.860
P	02:00:35:59.0	356.300	237.500	210.100	299.900	27.866	77.620	26.688	-3.666	0.930	-1.778
P	02:00:36:59.0	356.300	237.500	210.100	299.900	26.320	81.444	24.666	-3.300	0.940	-1.680
P	02:00:38:03.0	356.300	237.500	210.100	299.900	24.833	85.500	22.394	-2.860	0.940	-1.590
P	02:00:39:03.0	356.300	237.500	210.100	299.900	23.674	89.078	20.114	-2.442	0.930	-1.490
P	02:00:40:03.0	356.300	237.500	210.100	299.900	22.650	92.570	17.889	-1.995	0.888	-1.395

P	02:00:42:02.0	356.300 <th colspan="10">VEH ORB</th> <th rowspan="2">PAGE 2</th>	VEH ORB										PAGE 2	
			VEB3U	VEB3H	VEB3H	VEB3H	VEB3H	VEB3H	VEB3H	VEB3H	VEB3H	VEB3H		
P	02:00:42:02.0	356.300	2.600	237.500	259.100	210.100	299.900	21.005	99.310	13.220	-0.870	0.760	-1.090	T
P	02:00:43:02.0	356.300	2.600	237.500	259.100	210.100	299.900	27.490	102.580	10.833	-0.270	0.700	-0.950	T
P	02:00:44:08.0	356.300	2.600	237.500	259.100	210.100	299.900	20.020	106.220	8.080	0.420	0.600	-0.780	T
P	02:00:46:08.0	356.300	2.600	237.500	259.100	210.100	299.900	19.780	109.440	5.655	1.060	0.490	-0.650	T
P	02:00:46:08.0	356.300	2.600	237.500	259.100	210.100	299.900	19.633	112.580	3.200	1.740	0.370	-0.500	T
P	02:00:47:08.0	356.300	2.600	237.500	259.100	210.100	299.900	19.666	115.833	0.670	2.450	0.230	-0.360	T
P	02:00:48:09.0	356.300	2.600	237.500	259.100	210.100	299.900	19.080	121.114	356.556	3.670	0.000	-0.110	T
P	02:00:49:48.0	356.300	2.600	237.500	259.100	210.100	299.900	20.386	124.333	359.114	4.400	-0.140	0.030	T
P	02:00:50:48.0	356.300	2.600	237.500	259.100	210.100	299.900	20.880	127.666	361.666	5.220	-0.310	0.170	T
P	02:00:51:49.0	356.300	2.600	237.500	259.100	210.100	299.900	21.556	130.920	348.290	5.888	-0.450	0.350	T
P	02:00:52:49.0	356.300	2.600	237.500	259.100	210.100	299.900	22.360	134.224	346.070	6.610	-0.620	0.490	T
P	02:00:53:49.0	356.300	2.600	237.500	259.100	210.100	299.900	23.320	137.633	344.690	7.290	-0.780	0.630	T
P	02:00:55:48.0	356.300	2.600	237.500	259.100	210.100	299.900	25.688	144.466	340.330	8.674	-1.090	0.890	T
P	02:02:09:37.0	356.300	2.600	237.500	100.500	248.600	348.100	28.400	190.700	4.000	0.580	-0.050	0.640	T
P	02:02:10:37.0	356.300	2.600	237.500	100.500	248.600	348.100	28.400	190.700	4.000	0.390	-0.640	0.430	T
P	02:02:11:37.0	356.300	2.600	237.500	100.500	248.600	348.100	28.400	190.700	4.000	0.366	-0.566	0.040	T
P	02:02:12:37.0	356.300	2.600	237.500	100.500	248.600	348.100	28.400	190.700	4.000	0.210	-0.030	-0.330	T
P	02:02:13:37.0	356.300	2.600	237.500	100.500	248.600	348.100	28.400	190.700	4.000	-0.110	0.520	-0.710	T
P	02:02:13:37.0	356.300	2.600	237.500	100.500	248.600	348.100	100.500	248.600	348.100	0.420	-0.730	-0.930	T
P	02:02:15:20.0	356.300	2.600	237.500	100.500	248.600	348.100	100.500	248.600	348.100	0.340	-0.666	-0.190	T
P	02:02:13:20.0	356.300	2.600	237.500	100.500	248.600	348.100	100.500	248.600	348.100	0.160	-1.000	0.550	T
P	02:02:13:20.0	356.300	2.600	237.500	100.500	248.600	348.100	100.500	248.600	348.100	0.100	-0.666	0.920	T
P	02:02:15:20.0	356.300	2.600	237.500	100.500	248.600	348.100	100.500	248.600	348.100	0.040	-0.388	0.695	T
P	02:02:13:20.0	356.300	2.600	237.500	100.500	248.600	348.100	100.500	248.600	348.100	-0.010	0.000	0.690	T

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VEH ORB

BODY VECTOR/UNV POINTING

1

ONBOARD GMT

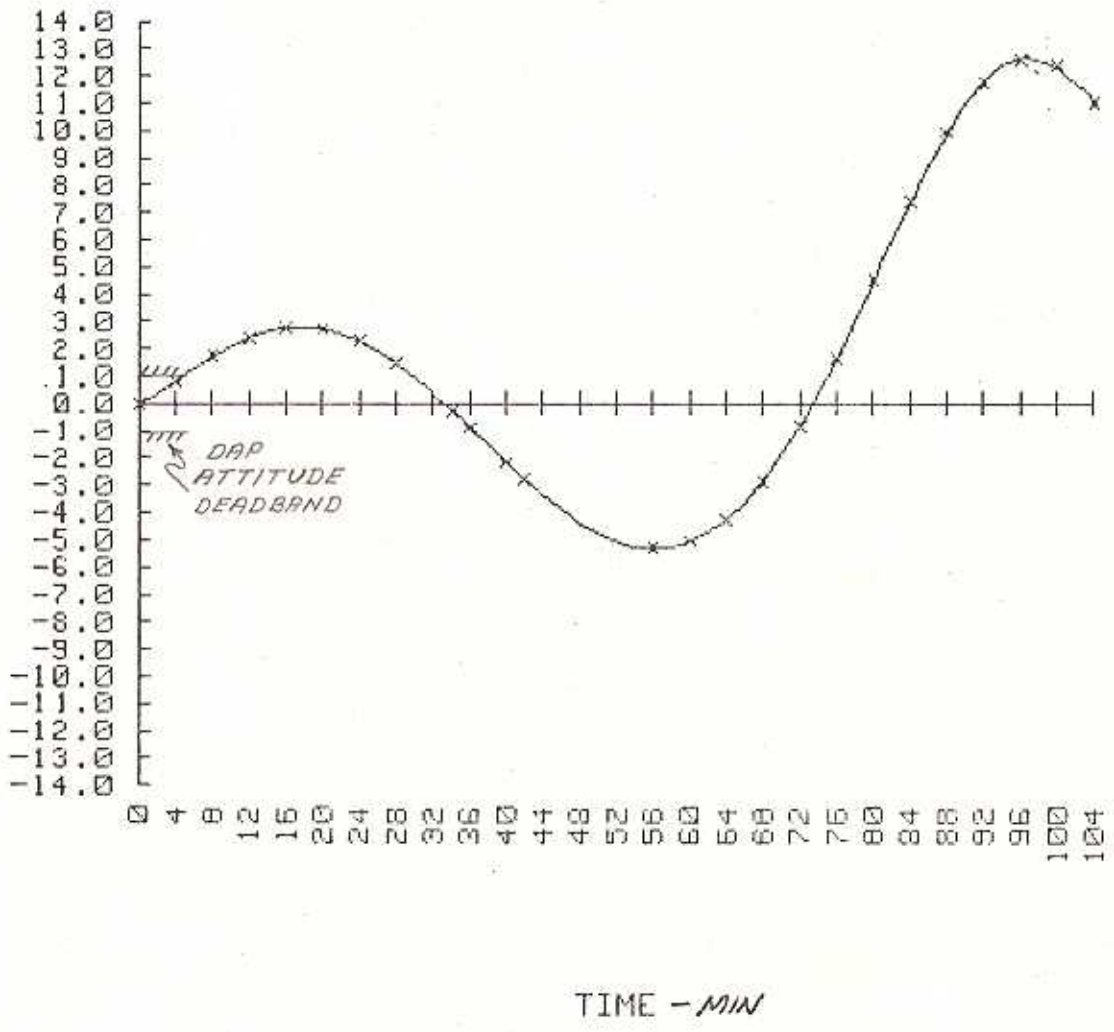






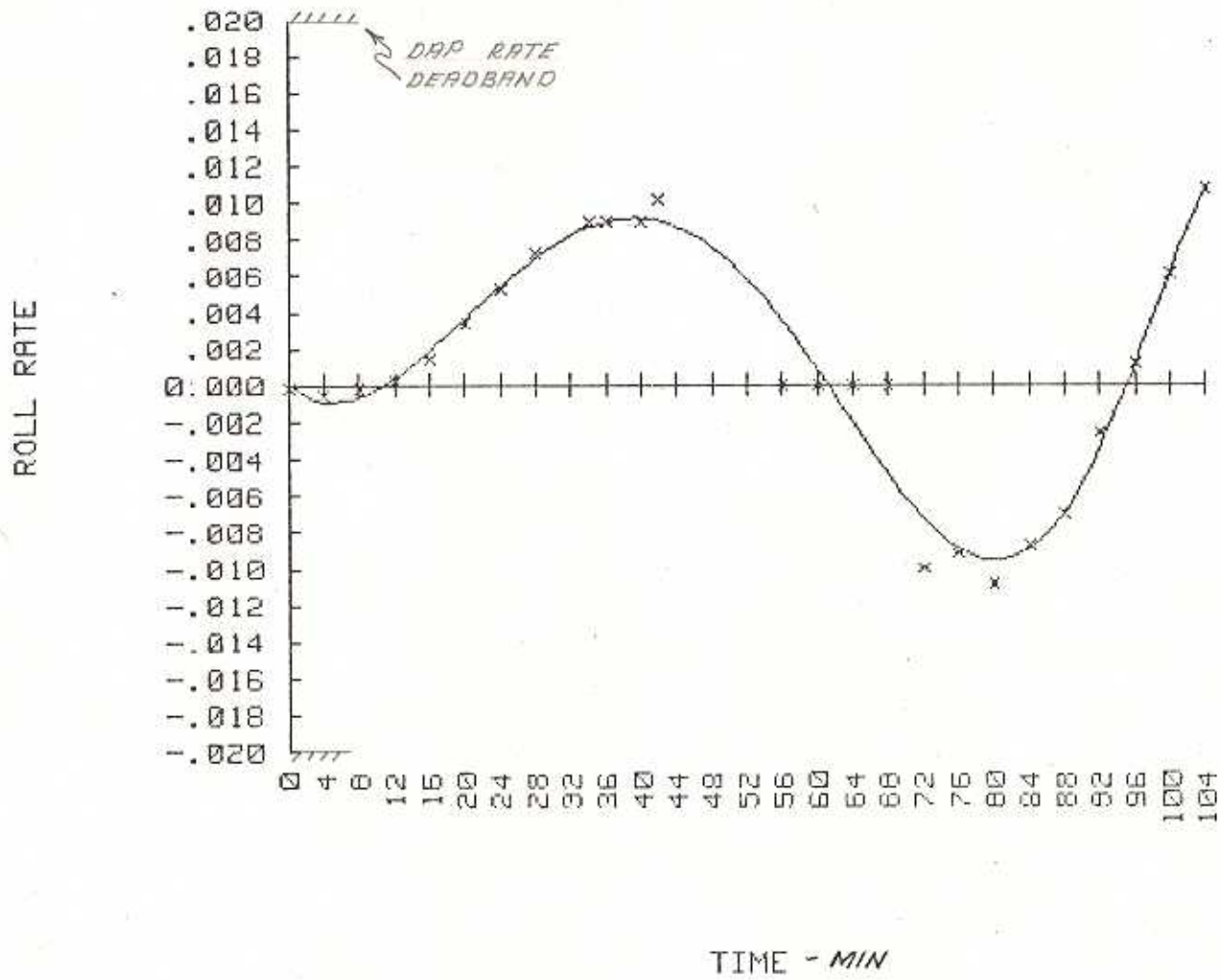
GRAVITY GRADIENT STS-3

ROLL ERR



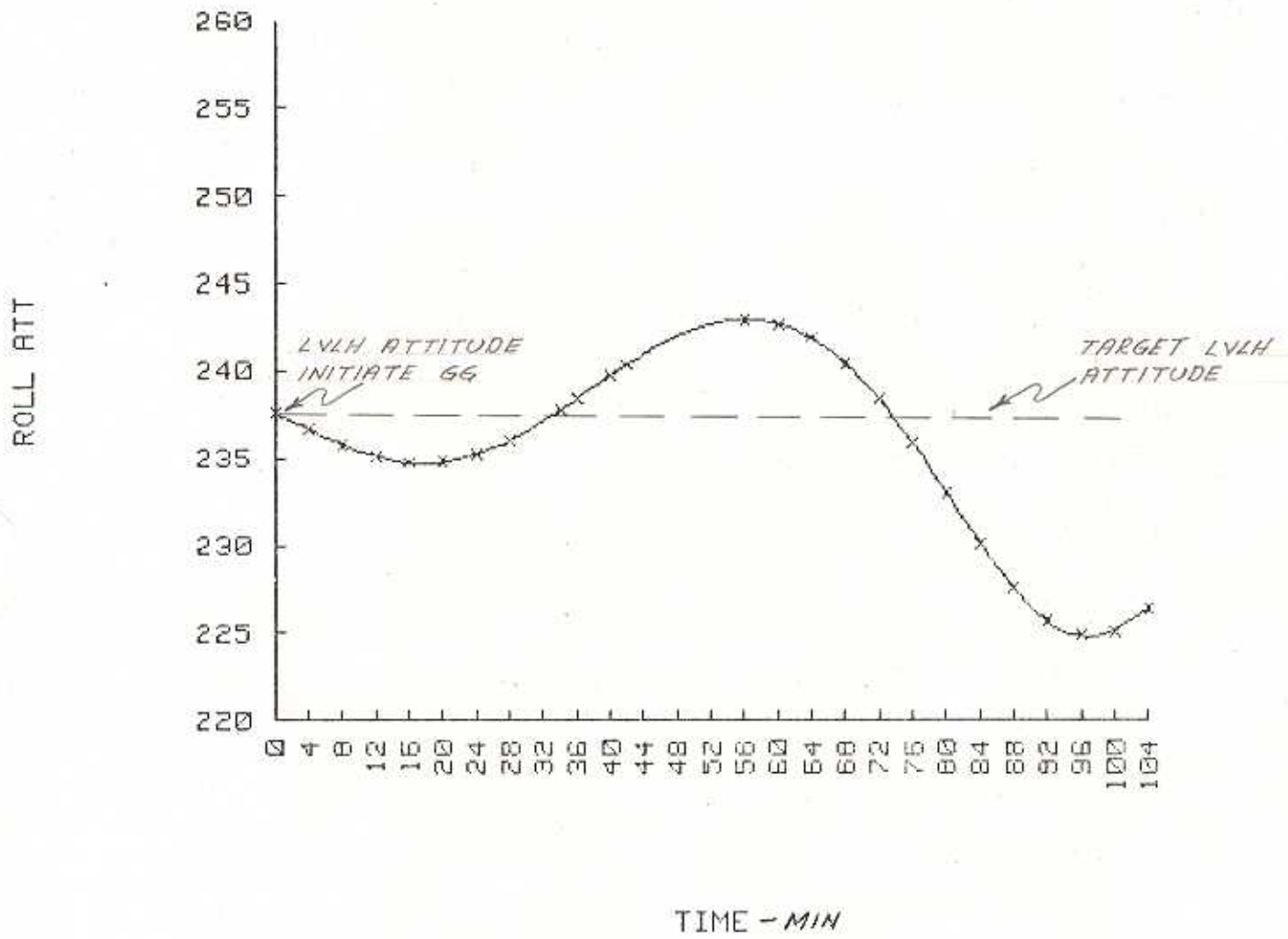


GRAVITY GRADIENT STS-3



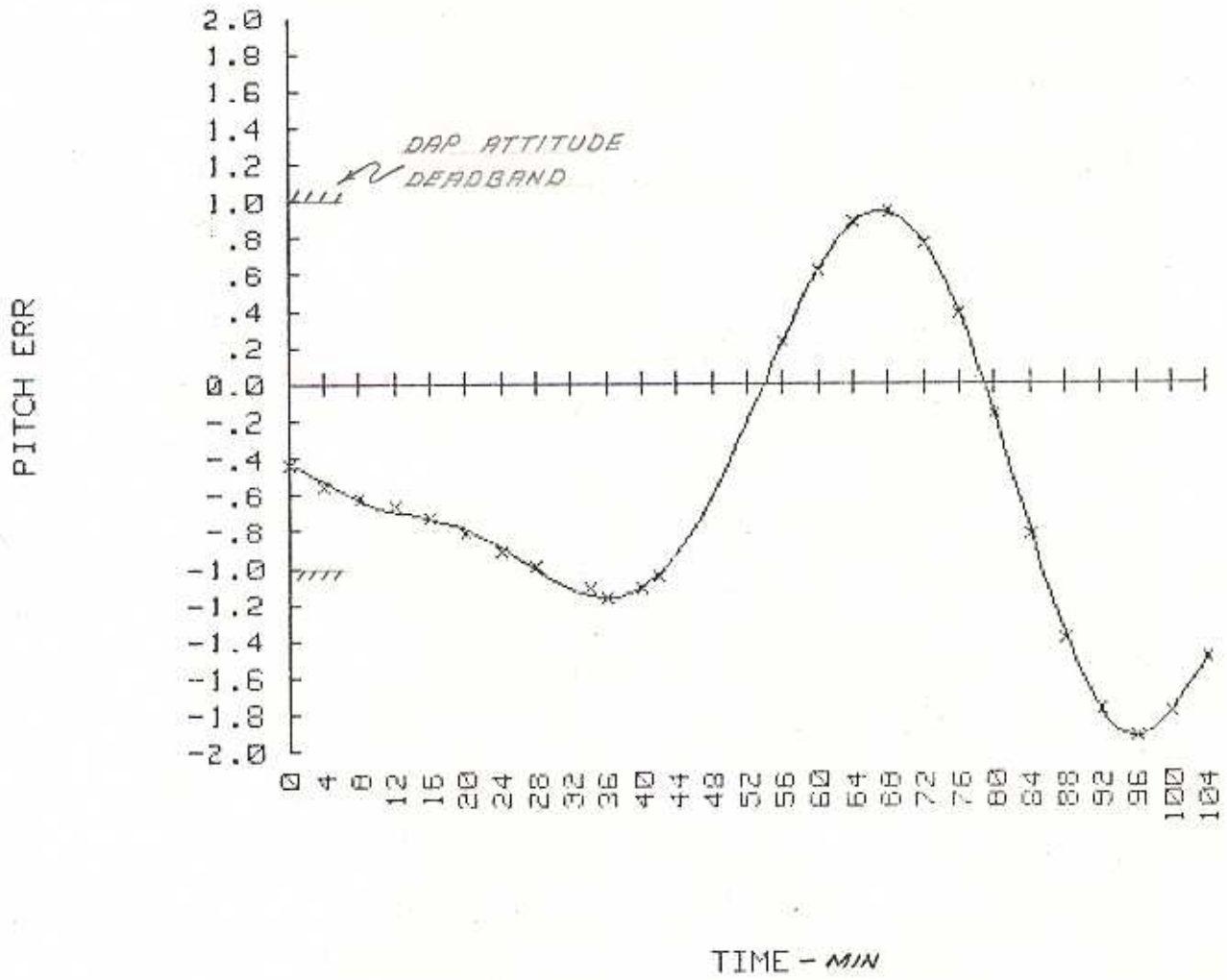


# GRAVITY GRADIENT STS-3



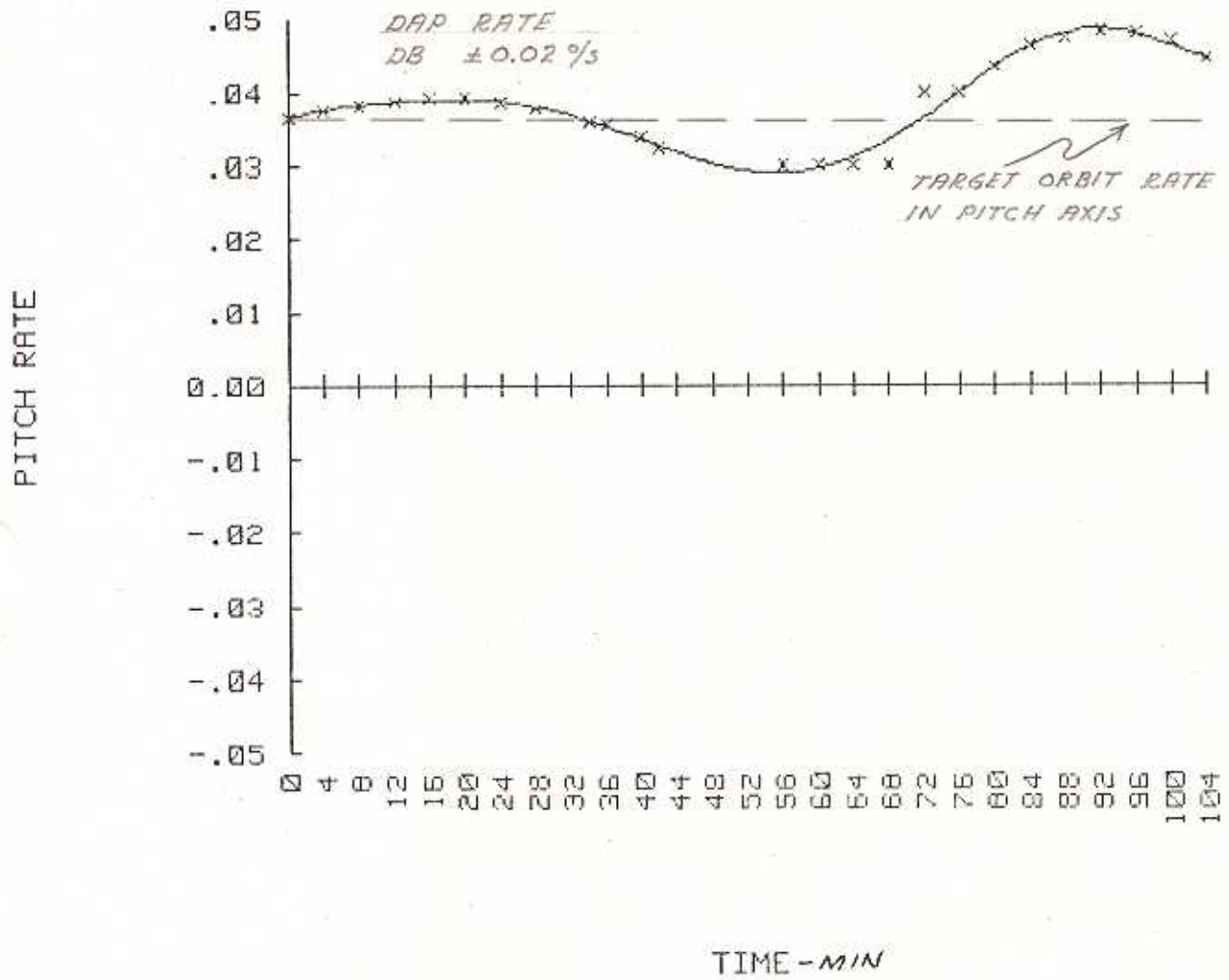


GRAVITY GRADIENT STS-3



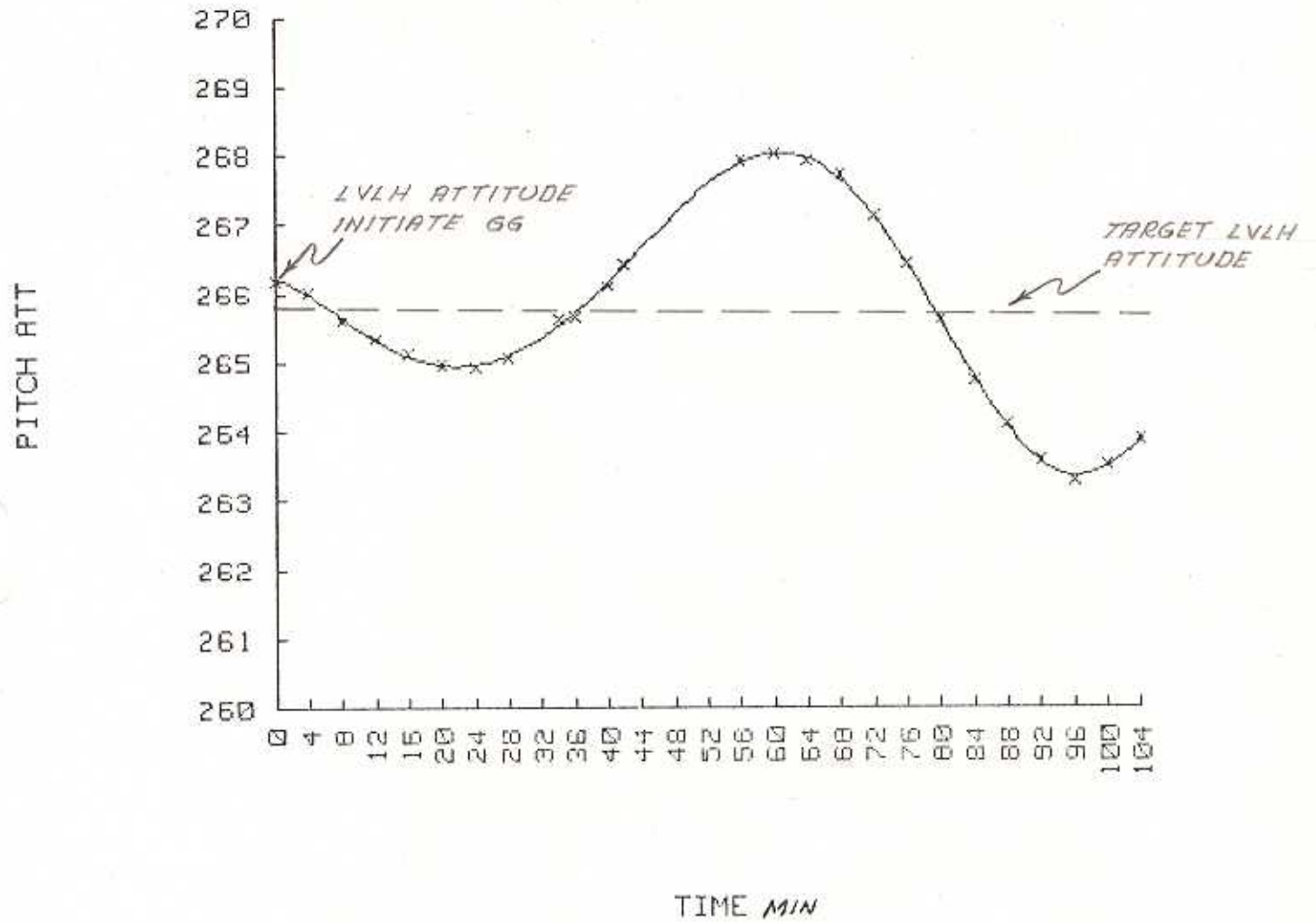


# GRAVITY GRADIENT STS-3





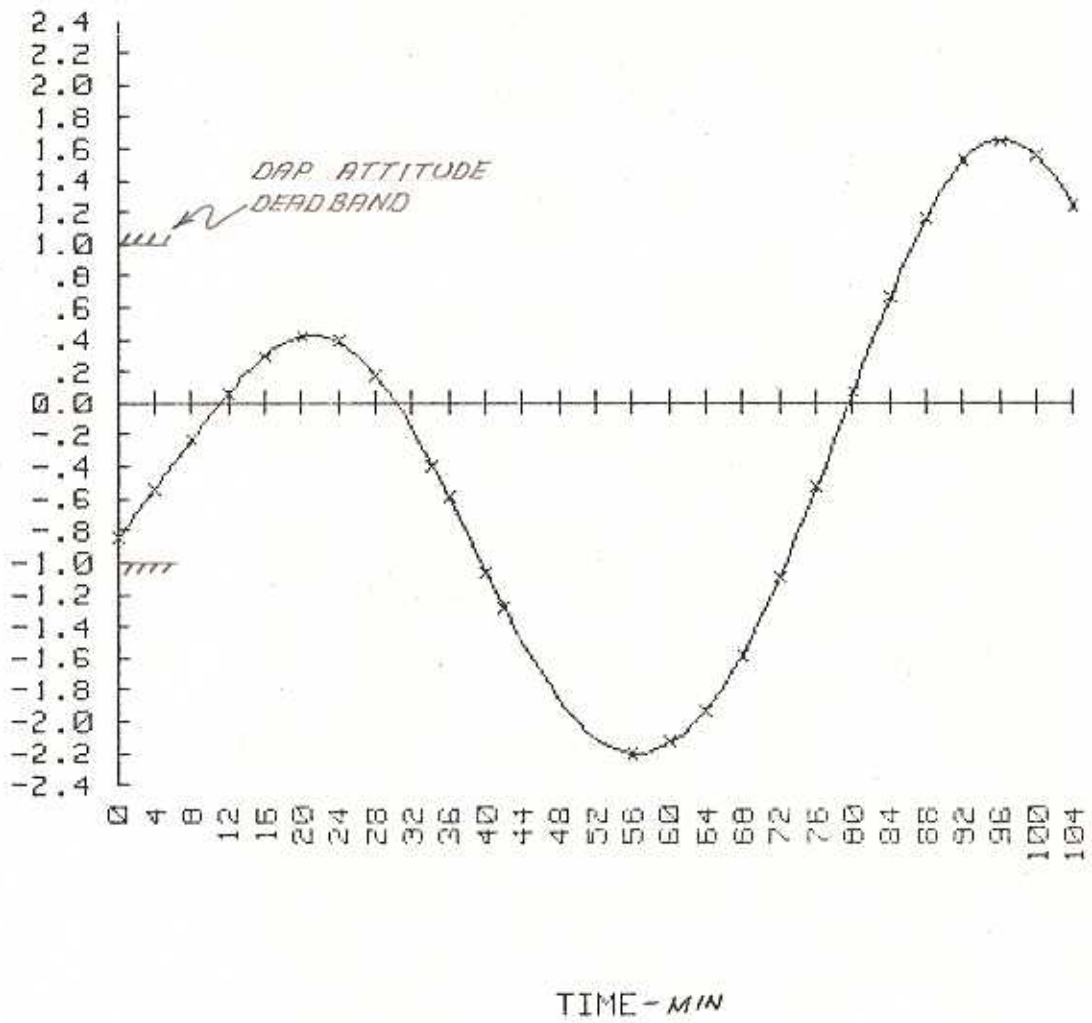
GRAVITY GRADIENT STS-3





GRAVITY GRADIENT STS-3

YAW ERR



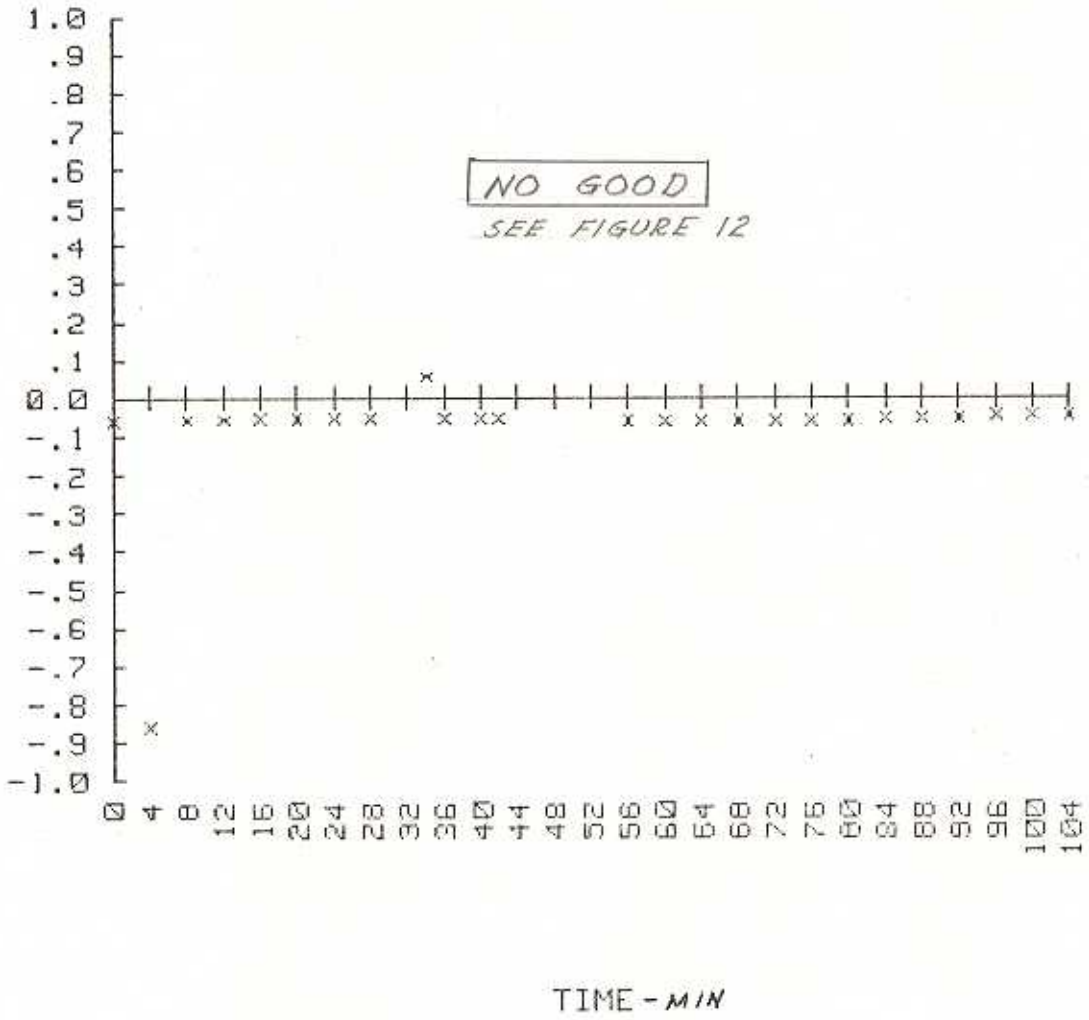
3.5.14

FIGURE 7



GRAVITY GRADIENT STS-3

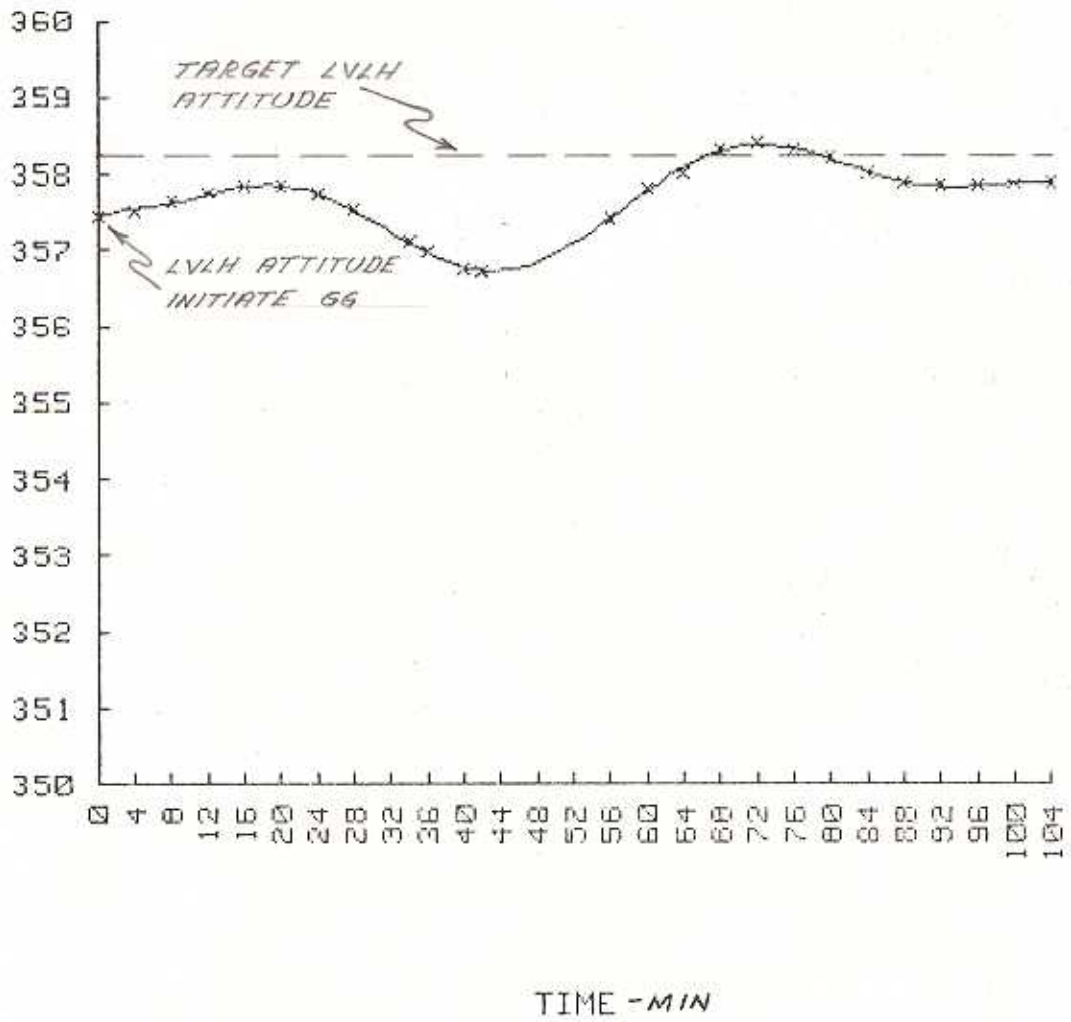
YAW RATE





GRAVITY GRADIENT STS-3

YAW ATT





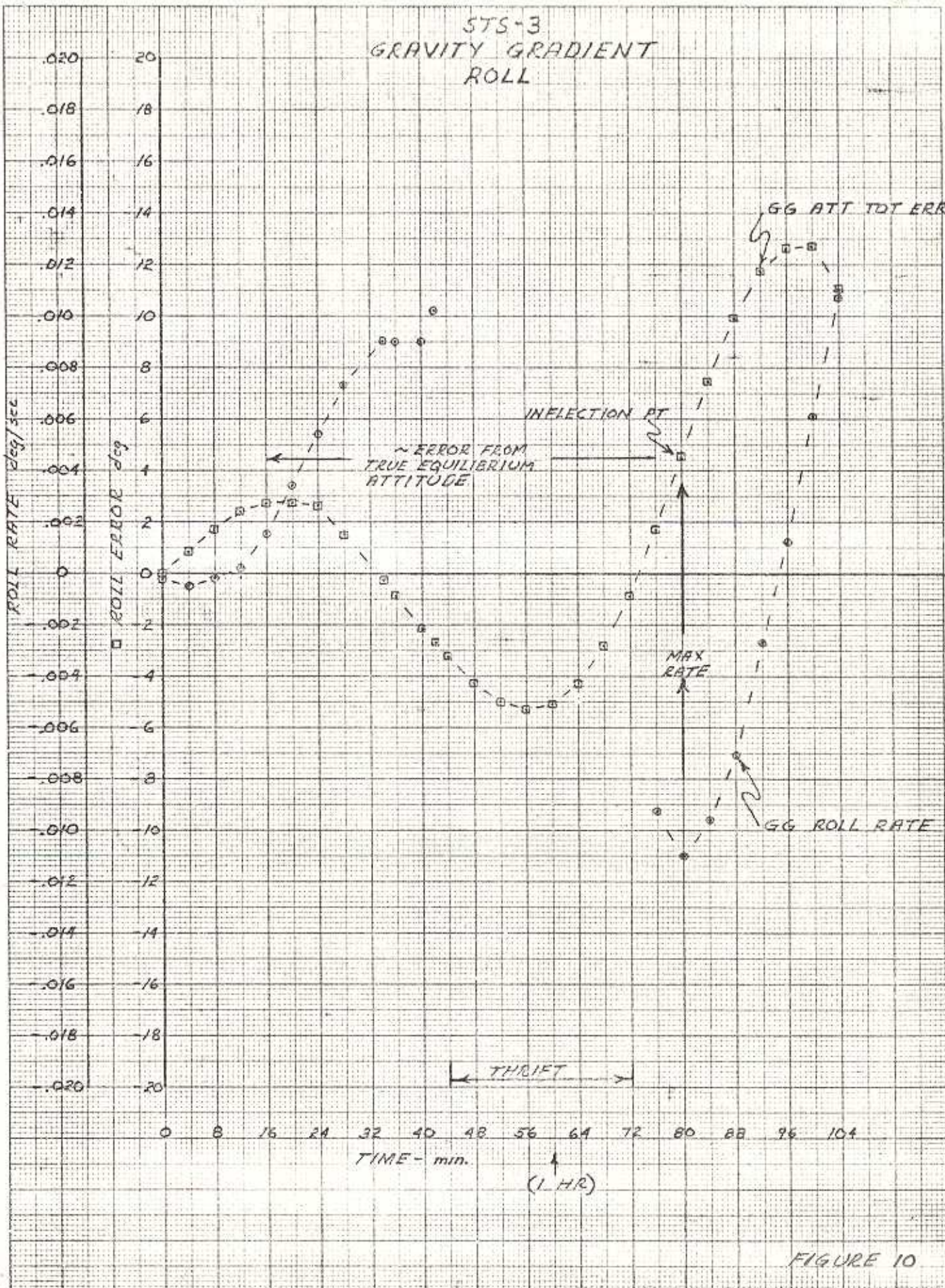


FIGURE 10



STS-3  
 GRAVITY GRADIENT  
 PITCH

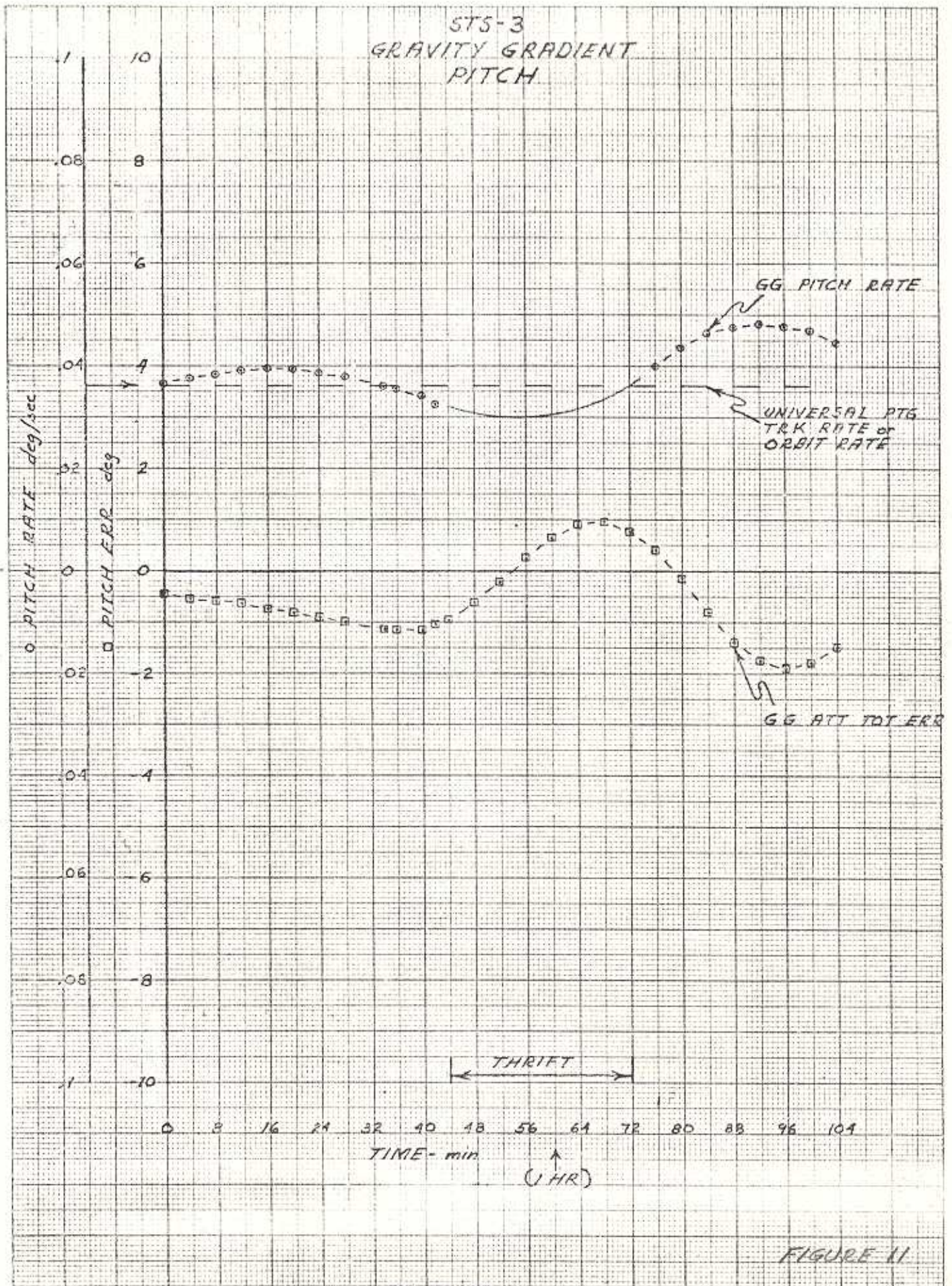


FIGURE 11

3.5.18



# STS-3 GRAVITY GRADIENT YAW

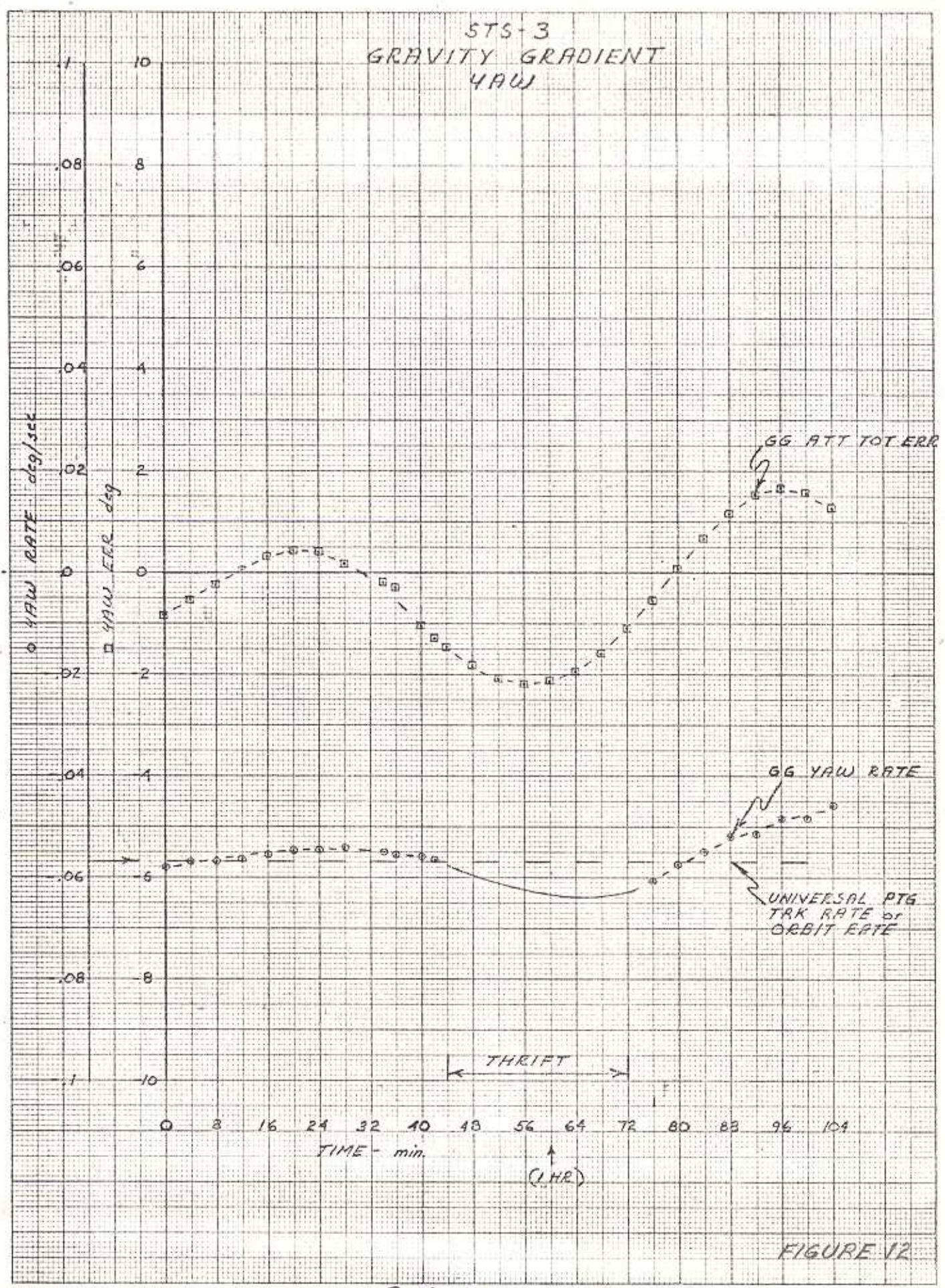


FIGURE 12

3.5.19



## ACCELEROMETER SYSTEM (AA)

### A. Performance

The AA performance during OPS 102 and OPS-3 was nominal. The AA data from the OPS-8 sensor self test satisfied the bias and limit test requirements in the PDP section 3, and in the SODB, volume 1, table 3.4.5.1-2. The AA power was left on in OPS-2 to protect the tungsten filament in the incandescent lamp.

#### STS-3 OPS-8 AA SELF TEST DATA

AA	AA BIAS DATA			
	LATERAL (Y)		NORMAL (Z)	
	BIAS	LIMITS	BIAS	LIMITS
1	-0.128	0.00±0.45	0.000	0.00±1.29
2	0.000	0.00±0.45	0.000	0.00±1.29
3	-0.064	0.00±0.45	-0.257	0.00±1.29
4	-0.064	0.00±0.45	0.000	0.00±1.29

AA	AA SELF TEST DATA			
	LATERAL (Y)		NORMAL (Z)	
	DATA	LIMITS	DATA	LIMITS
1	16.461	16.1±1.7	65.379	64.4±6.7
2	16.525	16.1±1.7	67.696	64.4±6.7
3	16.525	16.1±1.7	65.894	64.4±6.7
4	16.396	16.1±1.7	66.666	64.4±6.7

#### 1. Analysis of Problems:

- a. The accelerometer assemblies (AA) have a 500 HR limited life requirement, which is due to the tungsten filament in the lamp becoming brittle after so many operating hours. The STS-2 AA's were approaching 500 hrs and were scheduled for replacement prior to STS-3 checkout and flight. The AA's were replaced as follows, and are expected to last through STS-4 flight.

AA Changeout:	<u>AA1</u>	<u>AA2</u>	<u>AA3</u>	<u>AA4</u>
	STS-2 S/N-11	S/N-6	S/N-8	S/N-7
	STS-3 S/N-9	S/N-12	S/N-13	S/N-14

The AAs were left on throughout the flight to minimize the probability of the tungsten filament failure in the lamp.

- b. During OPS-8, the AA compensated data is downlisted incorrectly in FPS2, rather than G's as in OPS-1 and 3. Since the MOC converts the downlist data from G's to FPS2, the OPS-8 data in FPS2 is multiplied by 32.174 and displayed incorrectly on the ground.



The OPS-8 flight software release 20 (FLT 9) will change the AA downlisted data to G's, per CR 39946.

2. STS-2 & STS-3 data comparison

AA performance for both STS-2 and 3 was nominal, and the data compared favorably.

B. Lessons Learned

System performance was nominal, requiring no change in system operations.

C. Recommendations for Subsequent Activities.

1. LCC Limit Changes: None recommended
2. Flight Rule Changes: None required
3. SMS Parameter/Model Changes: None recommended
4. Console or MCC Procedure Changes:
  - a. Console procedure was implemented to transition from ASCENT to ORBIT MCC operations limit sense at MECO. This was done to support monitoring of OMS engine positions. This requires a MED input during prelaunch and MEDinput after transition to OPS 2 for AA operational ORBIT limit sensing.
  - b. The MCC ASCENT operational limit sensing for AA lateral selected acceleration is changed by MED inputs from  $\pm 0.3$  to  $\pm 5.0$  FPS2. This change is necessary to maintain the event light off during nominal operating conditions. The GNC Data Pack requirements will be revised to reflect this change for STS-5.
  - c. Perform SCP 3.2.16 (GN&C SYS. CNSL. H/B) to change AA calibration curve to correctly display the OPS-8 self test data in FPS2 for MCC real time display and post data analysis.
5. Data Retrieval Adequacy:

With MDRF submitts during the mission, data retrieval was excellent.



## AERO ACTUATORS

### A. PERFORMANCE

All aero actuators performed normally for all phases. There were several questions, as to why the elevon changed positions during OPS-2 while the ASA's and Hyd were off. This is a normal occurrence as described in the following analysis.

#### 1. Analysis of Elevon Position Changes in OPS-2.

Operation of the Hyd circulation pumps with the ASA's off will generally cause the elevon to drive to a hard stop. Once an imbalance is established in the servo values (with no command to position it) there is enough to move the elevon actuator. The imbalance may be in either direction, thus the elevon could move positive or negative.

Hyd circulation pump pressure is approximately 300 nsi, which is not high enough to switch the Hyd switching values to the elevon. This being the case, only circulation pump pressures to the standby 2 systems can get thru the switching values and drive the actuators. The standby 2 system to the four elevons are:

Hyd Sys 2 - Right inboard  
- Left outboard

Hyd Sys 3 - Right outboard  
- Left inboard

System 1 circulation pump will not drive the actuators.

*operational*  
*circ* The Body Flap, Rudder and Speedbrake are not affected by circulation pump operations as they have Hyd actuated brakes, which are not released at the low circulation pump pressure.

2. Comparison of dates STS-3 actuator signatures were very similar to STS-2.

### B. LESSONS LEARNED - NONE.

### C. Recommendations for Subsequent Activity.

1. LCC Limit Changes - NONE.
2. Flight Rule Changes - NONE
3. SMS Parameter/Model changes - Same comment from STS-2. The SMS outputs the Secondary Delta Pressure with a reverse sign to the actual vehicle. This needs to be fixed.
4. Console or MCC changes - NONE.
5. Data retrieval - NONE



## AIR DATA SYSTEM (ADTA)

### A. Performance

The ADTA performance during major mode 304 and 305 was nominal. The flight data was reviewed with no discrepancies noted. The major operational functions of the ADTA system are listed below:

89:15:58:21	ADTA PROBE DEPLOYED	MACH 3.1	HPC 94.5K
58:22	ADTA GOOD FLAG ON	MACH 3.1	HPC 94.5K
58:58	DATA ENABLED TO G&C	MACH 2.5	HPC 85.9K
59:06	DATA OUTPUT TO G&C	MACH 2.4	HPC 83.7K

The ADTA data from the OPS-8 sensor self test satisfied the BITE and limit test requirements in the PDP section 3, and in the SODB, volume 1, table 3.4.5.1-2. The same ADTA's have been on all three flights. The units for ADTA 1, 2, 3 and 4 were S/N 411, S/N 414, S/N 412, and S/N 410 respectively.

#### 1. System Changes to prevent Anomalies

##### a. LCC limit changes for STS-3 & SUBS

Air data probe stow redline:

1 of 2 deploy events equal "0" and 1 of 2 stow events equal "1" for each probe are mandatory. Visual backup for proper stow may be utilized.

##### b. Software change

To prevent false alarms and failures, the STS-3 ADTA RM same-side trip levels were revised by CR 39521 to compensate for the transducer drift rate biases expected thru STS-3, 4, and 5 flights.

#### 2. STS-2 & STS-3 data Comparison

ADTA performance for both STS-2 and STS-3 was nominal and the data compared favorably.

### B. Lessons Learned

Systems operation and performance was nominal. There are no recommendations to enhance vehicle or ground system operations.

### C. Recommendations for Subsequent Activities

1. LCC limit changes: NONE
2. Flight Rule changes: NONE
3. SMS Parameter/Model changes: NONE
4. Console or MCC Procedure changes:
  - a. The MCC Orbit & Entry event light operational limit sensing for ADTA 1/3 and 2/3 delta pressures are changed by MED inputs from 0.025 to 0.05 IN HG. The change is necessary to cover the expected ADTA pressure transducer bias drift during STS-3 through 5 missions.



The ADTA RM thresholds were adjusted for the transducer bias drift by CR 39521. The GNC Data Pack will reflect this change for STS-4.

5. Data Retrieval:

With pre-planned MDRF requirements and MDRF submittal during the mission, data retrieval was excellent.



0R16

STS-3 OPS 8 ADTA SELF TEST DATA

TRANS-DUCER BIAS				
ADTA	PS	PdC	PdU	PdL
1	0.002	-0.024	-0.021	-0.030
2	-0.021	0.000	-0.024	-0.027
3	-0.035	-0.014	-0.029	-0.010
4	-0.001	-0.016	0.010	0.008

ADTA HIGH TEST	PS	PdC		PdU		PdL		T		
		DATA	LIMITS	DATA	LIMITS	DATA	LIMITS			
1	0.8141	0.814±.001	5.4748	5.475±.002	2.7422	2.742±.002	1.7107	1.710±.002	173.580	173.63±.07
2	0.8141	0.814±.001	5.4748	5.475±.002	2.7422	2.742±.002	1.7107	1.710±.002	173.580	173.63±.07
3	0.8141	0.814±.001	5.4748	5.475±.002	2.7422	2.742±.002	1.7107	1.710±.002	173.580	173.63±.07
4	0.8141	0.814±.001	5.4748	5.475±.002	2.7422	2.742±.002	1.7107	1.710±.002	173.580	173.63±.07

ADTA LOW TEST	PS	PdC		PdU		PdL		T		
		DATA	LIMITS	DATA	LIMITS	DATA	LIMITS			
1	24.8884	24.888±.001	29.5277	29.529±.002	21.7089	21.710±.002	14.7138	14.715±.002	18.520	18.52±.02
2	24.8884	24.888±.001	29.5277	29.529±.002	21.7089	21.710±.002	14.7138	14.715±.002	18.520	18.52±.02
3	24.8884	24.888±.001	29.5277	29.529±.002	21.7089	21.710±.002	14.7138	14.715±.002	18.520	18.52±.02
4	24.8884	24.888±.001	29.5277	29.529±.002	21.7089	21.710±.002	14.7138	14.715±.002	18.520	18.52±.02



## ASCENT TVC ACTUATORS

### A. Performance

#### 1. SRB Actuators

The system functioned as advertised throughout the prescribed period of operation. SRB slew occurred at 81:15:59:36 with nominal tilt and rock actuator responses. The maximum secondary delta pressure recorded during this period was 440 PSI. Between SRB and slew and SRB separation channels 1 through 4 of each tilt and rock actuator of the left and right SRB's gradually increased to a maximum value with only minor deviations to this schedule. The highest secondary delta pressure noted was -847 PSI occurring at 15 second prior to SRB separation on the right SRB, channel 2 tilt axis. A history of these pressures is recorder in table I.

#### 2. SSME Actuators

SSME also performed as expected with no noted anomalies. There were two items, however, which bear mentioning. These items are (1) pitch oscillations as main engines are commanded to the stow position and (2) a slightly high secondary delta pressure after eight minutes of flight. During STS-1 and STS-2 excessive oscillations (.5<sup>o</sup> peak to peak and .6<sup>o</sup> peak to peak respectively) were noted while the main engines were being commanded to their dump position. STS-3 oscillations during this time compared very favorable only, 3.7<sup>o</sup> peak to peak. Also during previous flights there were jet firings associated with the excessive pitch rate oscillations; one firing during STS-1 and six firings during STS-2. However, during STS-3 there were no jet firings during this period since the oscillation never approached the pitch rate limits. CR 39360A, scheduled for version 19, STS-5 implementation will change the actuator movement rate and increment from 1HZ and 1<sup>o</sup>/step to 12.5 HZ and .08<sup>o</sup>/step. This action should reduce if not entirely eliminate the oscillations. Notice that the rate of engine movement is the same in both cases, 1<sup>o</sup>/sec. The other item worth describing is a high secondary delta pressure on the center main engine channel 4 pitch axis. Between MECO and ME stow the secondary delta pressure on the channel 4 pitch axis was observed to climb at a faster rate, and achieve a higher value than any other secondary delta pressure. The highest value noted was -1126 psi at 81:16:09:18. Had this value reached -1175PSI, the redundant channel equalization in ATVC 4 would have come into play to hold the pressure at -1175PSI. Since the same situation was encountered on previous flights, no serious anomaly is seen to exist here. See table II for pressure history.



## B. Lessons Learned

The SRB actuators have proven themselves through three flights. Although no circumstances have arisen to cause RM to bypass a channel, these actuators are reliable at least under the circumstances noted.

The SSME Actuator Pitch oscillations should be expected on STS-4 while the main engines are being commanded to the dump position. The magnitude of these oscillations should be between 3.7° and 6° peak to peak depending on how many jet firing are required to maintain the pitch rate within its deadband. Expect these oscillations to cease with STS-5. Also expect higher than average secondary delta pressure on channel 4 pitch axis of the center main engine actuator.

## C. Recommendations

1. LCC limit changes - none.
2. Flight rule changes - none.
3. SMS parameter/model changes - one SMS problem which was identified prior to STS-1 should be fixed as soon as possible. This is the problem that the SRB actuators cannot be bypassed because the channel override remains on. This override is reset normally when the pre-launch actuator slew test is run. This test is not done in the SMS. Better training would be provided if this problem was corrected.
4. Console or MCC procedure changes - none.
5. Data retrieval adequacy - none.



## L SRB

	ROCK				TILT			
	1	2	3	4	1	2	3	4
SRB SLEW 81:15:59:36	60	242	0	121	135	82	121	130
81:16:01:00	-60	-210	130	-250	242	-119	207	-293
SRB SEP 81:16:03:15	158	-378	268	-451	407	-365	317	-512

## R SRB

	ROCK				TILT			
	1	2	3	4	1	2	3	4
SRB SLEW 81:15:59:36	-40	-55	-60	-125	120	0	335	25
81:16:01:00	120	-548	120	-365	390	-646	240	-304
SRB SEP 81:16:03:15	120	-585	292	-512	427	-847	240	-292

All pressures in psi

TABLE 1



## C ME

	PITCH				YAW			
	1	2	3	4	1	2	3	4
LIFT OFF 81:16:00:00	335	24	168	-503	144	-48	216	-479
SRB SEP 81:16:03:15	335	-96	335	-599	192	-72	216	-527
MECO 81:16:08:34	479	48	240	-743	144	0	263	-503
SLEW 81:16:08:45	647	48	168	-886	48	0	192	-383
ET SEP 81:16:08:51	910	0	311	-1078	48	0	263	-479
81:16:13:37	743	24	359	-1102	96	0	335	-551
81:16:13:41	479	144	383	-886	96	-24	287	-479

## L ME

	PITCH				YAW			
	1	2	3	4	1	2	3	4
LIFT OFF 81:16:00:00	240	-216	263	-359	120	-383	407	-216
SRB SEP 81:16:03:15	168	-192	407	-431	168	-359	+335	-240
MECO 81:16:08:34	168	-144	407	-479	216	-287	359	-359
SLEW 81:16:08:45	240	-263	383	-335	263	-311	335	-335
ET SEP 81:16:08:51	287	-503	527	-335	263	-359	431	-383
81:16:13:41	120	-311	503	-383	120	-407	503	-263

All pressures in psi

TABLE II



## R ME

	PITCH				YAW			
	1	2	3	4	1	2	3	4
LIFT OFF 81:16:00:00	144	-168	311	-287	24	-72	0	0
SRB SEP 81:16:03:15	144	-96	263	-287	96	0	0	-144
MECO 81:16:08:34	335	-72	168	-359	192	-96	144	-240
81:16:08:47	144	144	335	-503	216	-96	144	-311
81:16:13:41	407	-48	311	-623	168	-48	72	-168

All pressures in psi

TABLE II con't

3.9.5



## COAS

### A. Performance

The performance of the COAS, in both the +X and the -Z locations, was good. As far as Accuracy, in the +X, the result was only a .11 degrees delta between the new I-load (changed from that on STS-1 and 2, see enclosed comparison data table), and the STS-3 cal vector. The new I-load was almost exactly the vector recorded on STS-2. Thus, the delta from STS-3 to STS-1 was .20 degrees. Similarly, the COAS accuracy in the -Z location was remarkable. No calibration had been done on the -Z prior to STS-3, but two calcs were done on separate days for this flight. Thus, some data for comparison was available. The resulting delta from the I-load to the first cal bias vector was .47 degrees and from the I-load to the second cal bias vector was .58 degrees. However, the delta between the two recorded cal bias vectors was only .15 degrees. This compares with the accuracy available in the +X location. This repeatability indicates that ascent and entry forces do not harm the accuracy of the instrument. Similarly, the repeated action of removal and reinstallation of the unit appears to have a negligible effect.

For the -Z calcs, we were in different thermal attitudes (nose-sun first, then top-sun). Thermal effects appear to be small at these attitudes by the resultant vectors.

1. Analysis of problems = none.
2. Comparison data = see enclosed table.

### B. Lessons Learned

The system performs better than anticipated and the repeatability is remarkable.

### C. Recommendations

1. LCC limit changes = none.
2. Flight rule changes = none.
3. SMS changes = none.
4. Procedure changes



As is obvious from the -Z data in the table, the I+ loaded bias vector is not the best available. However, a guess as to which vector is more correct would be just that--a guess. We recommend that an FTO be made for STS-4 to cal the COAS in the -Z. Considering the larger delta (.15 degrees) and the change in thermal conditions, it is advisable to get one more cal test.

5. Console changes = none.

6. Data retrieval adequacy = none.



COAS PERFORMANCE DATA

-Z COAS CAL BIAS VECTOR (UNITIZED)

	$\frac{X}{Y}$	$\frac{Z}{Y}$
I-LOAD	-0.183951395	-0.982935341
1ST CAL	-0.175963093	-0.984396323
2ND CAL	-0.174054981	-0.984735155

$\Delta$  I-LOAD TO 1ST CAL = 0.475618795 deg  
 $\Delta$  I-LOAD TO 2ND CAL = 0.585097125 deg  
 $\Delta$  1ST CAL TO 2ND CAL = 0.153076985 deg

+X COAS CAL BIAS VECTOR

I-LOAD (STS 1&2)	0.982976243	-0.000363610	-0.183732341
I-LOAD (STS 3)	0.983470572	0.002123277	-0.181055585
STS -1	0.983443414	0.003739170	-0.181176903
STS -2	0.983470583	0.002123276	-0.181055530
STS -3	0.983545494	0.000228661	-0.180660479

$\Delta$  I-LOAD 1 TO I-LOAD 3 = 0.211249792 deg  
 $\Delta$  I-LOAD 1 TO STS -1 = 0.278232018 deg  
 $\Delta$  I-LOAD 1 TO STS -2 = 0.211252123 deg  
 $\Delta$  I-LOAD 1 TO STS -3 = 0.182189535 deg  
 $\Delta$  I-LOAD 3 TO STS -2 = 0.000000000 deg  
 $\Delta$  I-LOAD 3 TO STS -3 = 0.110971804 deg  
 $\Delta$  STS -1 TO STS -2 = 0.092857746 deg  
 $\Delta$  STS -1 TO STS -3 = 0.203386241 deg  
 $\Delta$  STS -2 TO STS -3 = 0.110971064 deg



## CONTROLLERS (RHC/THC/RPTA/SBTC)

### A. Performance

The rotational hand controller (RHC), translation hand controller (THC) rudder pedal transducer assembly (RPTA), and speedbrake thrust controller (SBTC) systems performed satisfactory throughout the mission with no anomalies noted. The units on STS-3 were as follows: CDR RHC S/N 9, PLT RHC S/N 2, AFT RHC S/N 8, FWD THC S/N 2, AFT THC S/N 3, CDR SBTC S/N 5, PLT SBTC S/N 4, CDR RPTA S/N 5 and PLT RPTA S/N 4.

#### 1. Anomalies

No anomalies were noted during the STS-3 mission.

#### 2. STS-1 vs STS-2 vs STS-3:

- a. It was noted during STS-1 that there was a possible problem with transients when the controller power switches were cycled. When power was turned off on the RHC, it was possible to inadvertently downmode the DAP. Also, when controller power switches were turned on, the THC could cause transient jet fire commands. Between STS-1 and STS-2 on-orbit DAP deadband values were adjusted. The crew did not report any on-orbit DAP inadvertent firing; however, there were transient firing in trans DAP. No transient firing were reported on STS-3 for either the on-orbit DAP or trans DAP. Rockwell is still working on a hardware design change to insure resolution of transient firing resulting from controller power switch cycles.
- b. Similar RHC + roll trim B contact failures reported on STS-2 did not occur on STS-3. The Cicoil Wire vs New England Wire issue is still active with its status unchanged from the STS-2 post mission closeout report.
- c. It was noted during the RMS/PRCS unloaded test-part 1 that when the crew made a + roll input to the AFT RHC, a small -YAW input was also present. A more indepth explanation can be found in the ORBIT DAP portion of this report. No hardware or software deficiencies are anticipated.

### B. Lessons Learned - NONE

### C. Recommendations for Subsequent Activities

1. LCC limit changes - NONE
2. Flight rule changes - NONE
3. SMS parameter/model changes - follow the possible hardware design change proposed by Rockwell to overcome transient firings (2.(a) ).
4. Console or MCC procedure changes - NONE
5. Data retrieval adequacy - NONE



## DEDICATED DISPLAYS

### A. Performance

The dedicated displays covered in this report include the ADI's, AMI's, AVVI's, HSI's and the SPI. The performance of these displays cannot be evaluated by ground personnel since there is no "feedback" from the displays on TLM. During the OPS-8 FCS check-out, the crew performed the DD check-out as per the procedure on page 3-16 of the STS-3 DEORBIT PREP, SEC 3-12 checklist. The DD check-out was performed during LOS with no report of any anomalies during the flight or during the crew post-mission debriefings. A look at the THRIFT data (1 sample per minute) post mission indicated the following:

GMT 87:14:16:16.0	LOW TEST
87:14:21:16.0	HIGH TEST
87:14:22:16.0	FLAG TEST
87:14:23:16.0	OFF

The TLM data had all the correct test values for all the analog data and the control words for the flag test.

#### 1. ANOMALIES

During the STS-2 de-briefing, the crew reported that the Accel, Mach/Vel, and EAS tapes appeared to drive slower than normal on the AMI display. Subsequent investigation revealed that the flight hardware was operating at the correct rates, but the SMS is being driven at higher rates. The STS-3 crew was briefed on this pre-flight and an SSR (Simulation Support Requirement) #422 dated 2/1/82 was prepared to fix the SMS.

### B. LESSONS LEARNED - NONE

### C. RECOMMENDATIONS FOR SUBSEQUENT ACTIVITIES

1. LCC Limit changes: NONE
2. Flight Rule changes: NONE
3. SMS Parameter/Model changes: NONE
4. Console or MCC Procedure changes: NONE
5. Data Retrieval Adequacy: NONE



## IMU

### A. Performance

The units installed in slots 1, 2, and 3, respectively, were S/N 18, S/N 11, and S/N 12 (no change from STS-2). All IMU operations allowed a 24-hour warmup period before commanding operate.

Similar to STS-2 preflight testing, IMU 3 demonstrated higher drift rates than IMUs 1 and 2 during preflight. During CDDT and a special L-10 day hangar calibration run, IMU 3 drifted at a .05 - .06 deg/hr rate about the X-axis. While on the pad, the X axis of IMU 3 points predominantly up (opposite the G vector), which is the axis about which drifts can not be measured with the accelerometers. The community has concluded that IMU 3 has a higher drift about the UP axis which won't be calibrated out during prelaunch cals. The observed drift summed high in comparison with IMUs 1 and 2, but in reality the UP axis drift was only 2 $\sigma$  for IMU 3. The launch day drift on IMU 3 was much smaller, which matches its performance during STS-2 launch day ops.

During the flight, the IMUs performed well in both attitude and velocity channels, with a few minor exceptions. The gyros required constant bias updates to zero the drifts, but the updates were small for the most part. The table below lists the times and torquing angles of the 18 alignments performed on STS-3.

ALIGNMENT TORQUING ANGLES (DEG)									
TIME (MET)	IMU 1			IMU 2			IMU 3		
	X	Y	Z	X	Y	Z	X	Y	Z
0:06:40:00	.14	-.08	-.09	-.10	.09	.14	-.04	.09	-.14
0:10:34:20	.00	-.08	-.10	-.09	-.07	.04	-.06	.09	-.10
0:22:01:40	.02	-.03	-.29	-.44	.00	.10	-.04	.19	-.33
1:10:14:00 *	.00	.00	.00	-.20	-.04	.08	-.03	-.01	-.07
1:22:30:00 **	.23	.12	.16	-.17	.00	-.10	.01	.17	-.36
2:09:30:00 **	.16	.19	.03	-.09	.05	.19	-.02	.11	-.47
2:21:13:00 **	.11	-.03	.19	-.17	.06	.14	.02	.04	.04
3:07:35:00 **	.08	-.01	.13	-.15	.09	.11	.02	.09	.03
3:23:40:00 **	-.01	.06	.17	-.11	.04	-.01	.01	-.01	.08
4:20:36:00 **	.01	.10	.08	-.13	.00	-.06	.02	.05	.08
5:09:03:12	.11	.04	.10	-.17	-.02	-.11	-.03	.09	.17
5:21:02:11	.01	.05	.27	-.21	-.07	-.33	-.13	.05	.49
6:08:57:00	.03	.06	.07	-.07	.15	-.01	-.05	.08	-.01
6:18:48:00	.09	.11	-.09	.01	.19	.09	.21	.12	-.28
7:00:40:00	-.02	.00	-.14	-.04	.00	.11	-.05	.08	-.02
7:05:54:00 **	-.01	-.01	-.16	-.07	-.01	.09	-.09	.09	-.01
7:17:24:00	.05	.09	-.28	-.12	-.05	.19	-.07	.12	-.04
7:21:21:00	-.03	.05	-.03	.03	.02	-.05	-.01	.07	.03

\* IMU/IMU ALIGNMENT IN LIEU OF STAR ALIGN - IMU 1 USED AS REFERENCE  
 \*\* STAR OF OPPORTUNITY ALIGNMENT

Using the above torquing angles drifts were computed and are listed below.



IMU DRIFT RATES (DEG/HR)

TIME	IMU 1			IMU 2			IMU 3		
	X	Y	Z	X	Y	Z	X	Y	Z
0:10:34:20	.000	.020	.026	.023	.018	-.010	.015	-.023	.026
<sup>1</sup> 0:23:17:34	-.002	.003	<u>.025</u>	<u>.038</u>	.000	-.009	.003	-. <u>017</u>	<u>.029</u>
1:22:30:00	-.019	-.010	-.013	.014	.000	.008	-.001	-.014	.029
<sup>2</sup> 2:09:16:30	-. <u>017</u>	-. <u>017</u>	-.005	.008	-.004	-.012	-.001	-.008	<u>.047</u>
<sup>3</sup> 3:07:09:00	-. <u>009</u>	.000	-.008	<u>.014</u>	-.004	-. <u>016</u>	.001	-. <u>013</u>	-.006
<sup>4</sup> 3:20:07:00	.000	-.002	-. <u>012</u>	<u>.006</u>	-. <u>006</u>	.000	.002	.002	-. <u>004</u>
4:11:45:00	-.002	-.007	-.005	.003	-.002	.002	-.001	-.003	-.008
5:09:03:12	-.009	-.003	-.008	.014	.002	.009	.002	-.007	-.014
<sup>5</sup> 5:14:52:41	0	0	0	0	0	0	0	0	-.06
<sup>6</sup> 5:23:49:00	-.001	-.004	-. <u>023</u>	<u>.018</u>	<u>.006</u>	<u>.028</u>	<u>.011</u>	-.004	-. <u>012</u>
6:08:57:00	-.003	-.002	-.001	.002	-.017	-.006	-.003	-.004	.009
<sup>7</sup> 6:20:25:00	-.009	-.011	.009	-.001	-. <u>019</u>	-.009	-. <u>021</u>	-.012	<u>.028</u>
<sup>8</sup> 7:05:54:00	.002	.002	.031	.013	.002	-.017	.017	-.017	.002
7:18:40:00	-.004	-.008	<u>.024</u>	.010	.004	-. <u>017</u>	.006	-.010	.003

- <sup>1</sup> Uplinked to underlined axes based on align data at 0:22:01:40.
- <sup>2</sup> Uplinked to underlined axes. Based on star of opportunity data at 2:05:57:00.
- <sup>3</sup> Uplinked to underlined axes. Based on star of opportunity data at 3:06:21:00. Due to previous data, only used -.012 for 2Z, and -.01 for 3Y.
- <sup>4</sup> Uplinked to underlined axes. Based on star of opportunity data at 3:15:17:00.
- <sup>5</sup> Uplinked to 3Z only. Used relative data. Update performed during crew sleep.
- <sup>6</sup> Uplinked to underlined axes. Originally updated only 1Z and 2X at 5:23:49:00. Performed second uplink at 6:05:06:55 to update the rest of the axes. All updates based on align data at 5:21:02:11.
- <sup>7</sup> Uplinked to underlined axes. Based on align data at 6:18:48:00.
- <sup>8</sup> Uplinked to underlined axes. Based on align data at 7:17:24:00.

By examining the above drift rates, one can see some changes in platform characteristics, either due to attitude changes, time, or possibly resolver instabilities. After reviewing graphs of the drifts versus the differing thermal attitudes for STS-3, it appears that inertial attitude changes may be contributors but are not totally responsible for the varying drift characteristics. Some axes were fairly stable after the initial compensation was performed, but others varied widely throughout the flight. As reported in the STS-2 post flight report, this phenomenon is still being investigated and is not understood at this point.

Unlike the platform drift performance, the accelerometers were very stable with one exception; the X-Y accelerometer on IMU 3 shifted approximately 350 $\mu$ g 14 1/2 hours into the mission. This anomaly will be discussed further in the problem analysis section of this report.

Listed below are the accelerometer biases measured during the flight.

### ACCELEROMETER BIAS (MICRO-G)

UPLINK TIME	IMU 1			IMU 2			IMU 3		
	X	Y	Z	X	Y	Z	X	Y	Z
0:04:37:00	<u>35</u>	<u>-15</u>	<u>21</u>	<u>-16</u>	<u>-16</u>	<u>40</u>	<u>6</u>	<u>-10</u>	<u>17</u>
0:15:00:00	2	-2	-9	2	-25	-5	<u>-321</u>	<u>383</u>	5
2:05:57:00	0	<u>-10</u>	-2	-4	<u>-10</u>	-2	-2	<u>-10</u>	<u>50</u>
5:09:44:00	<u>-7</u>	<u>-4</u>	<u>-12</u>	<u>-15</u>	<u>-13</u>	<u>5</u>	<u>-6</u>	<u>-4</u>	<u>-55</u>
6:12:29:35	-2	4	<u>-13</u>	2	<u>12</u>	6	-4	5	<u>49</u>

Only the underlined axes were updated.

Some oscillations in the biases are apparent, but these are fairly small and didn't present any problem to RM or NAV.

#### 1. Problem Analysis

##### a. Gyro Drift Variations

As stated before, this problem is not fully understood, but certainly causes problems in trying to compensate for gyro drifts. After STS-2, the predominant thinking was that the variations were due to orientation sensitivities; i.e., when inertial attitude changes occur, the gimbal angles change, and the result is that the drift characteristics change. With this flight, though, plots of drifts versus attitude changes don't totally support this theory.

A second possibility for the variations observed is that variations in NAV base temperatures caused deflections in the NAV base, and thereby resulted in variations in the drift rates. Looking at NAV base temps and plotting them against drift characteristics, the plots do not support this theory.

A third possibility, and one that needs further investigation, is that the resolvers are not as linear as we had thought. It is possible that the resolvers do not read the correct angles at certain gimbal angles. Harmonic errors in the resolvers are a well known phenomenon, and maybe the harmonic oscillations are the errors we observed. The resolver angles in a common frame are being plotted versus time to investigate this possibility. It is likely that we are seeing a combination of orientation sensitivity and some resolver errors that are not understood.

##### b. IMU 3 X-Y Accelerometer Shift

As previously stated, at approximately 0:14:30:00, the X-Y accelerometer on IMU 3 produced a level bias shift of -321  $\mu\text{g}$  in the X axis and 383  $\mu\text{g}$  in the Y axis. This shift represents a 6-7 sigma change in accelerometer bias. Once the new bias was compensated, however, the instrument remained stable for the remainder of the flight.

Similar failures have occurred during lab testing. One of the failures was isolated to particle contamination in the accelerometer itself while another failure was isolated to a 10V regulator. The 10V regulator failure is a triaxial-type failure, unlike the two axis shift observed on STS-3. The likely cause of the shift, then is thought to be particle contamination



in the X-Y accelerometer. The bias shift occurred early in the flight (0:14:30:00) and remained at the new level for the remainder of the flight. The shift is of sufficient concern, however, that S/N 12 has been removed and replaced with a spare IMU, S/N 16.

## 2. Comparison of STS-3 Data with Previous Flight Data

STS-3 flew the same IMUs as STS-2, but STS-1 had a different IMU 3. Other changes were the method of computing accelerometer biases, and the method of gathering star data for alignments. For STS-1, we had specific call-outs in the CAP for accelerometer calibrations where the vehicle had to be in free drift for approximately six minutes of site coverage. We gathered data and ran an off-line HP9845 program to compute the bias. For STS-2, we deleted the call-out in the CAP and gathered data over one rev to negate the effects of jet firings and vents. We then ran the off-line program to compute the bias and compared it with the new null bias comp on our display. After STS-2 and sims for STS-3, we felt comfortable with the null bias comps and used them exclusively for STS-3.

Because of the thermal attitudes on STS-3, we felt that we would be sweeping enough sky with the star trackers to warrant leaving both trackers powered for the entire flight. As a result, several sets of stars of opportunity were gathered and a few of these sets were used to align the IMUs, starting with the alignment at 1:10:14:00. The alignment interval was the same for STS-2 and STS-3 (approximately 12 hrs) vice the 8 hour interval for STS-1.

With the exception of the X-Y accelerometer shift on IMU 3, the performance on STS-3 is nearly identical to the previous two flights. With the longer flight on STS-3, the gyros and accelerometers required more updates, but the updates were the same order of magnitude as the updates on the first two flights. The accelerometers continue to be, for the most part, very stable. The gyros, however, drift due to some unknown error source and the resolvers, it appears, are varying in accuracy as a function of attitude. On the whole, though, the platforms are stable and performed well. The small variations in performance required "tweaks" on the platforms, which were easily accomplished by bias updates.

In an attempt to compare the IMU performance during entry, the misalignments just prior to landing are shown below.

		<u>STS-1</u>			
	X	Y	Z	RSS	
IMU 1/2	.06	-.12	-.05	.14	
IMU 1/3	.01	-.01	-.07	.07	IMU 1
IMU 2/3	-.05	.12	-.02	.13	COORDINATES

	<u>STS-2</u>				
	X	Y	Z	RSS	
IMU 1/2	.05	.04	.01	.06	
IMU 1/3	.03	.04	.04	.06	IMU 3
IMU 2/3	-.02	.00	.03	.04	COORDINATES

	<u>STS-3</u>				
	X	Y	Z	RSS	
IMU 1/2	-.03	-.03	.05	.07	
IMU 1/3	-.01	-.04	-.03	.05	IMU 1
IMU 2/3	.02	-.01	-.08	.08	COORDINATES

The misalignments for STS-1 were somewhat larger than the next two flights, which likely reflects increasing overall skill at compensating the platforms. The entry alignment was performed at TIG - 1 hr 50 min for all three flights.

#### B. Lessons Learned

The STS-2 post flight report stated that IMUs were being updated too frequently and updates should not be performed unless the drifts exceed .02 deg/hr. Experience on this flight, however, has shown that in stable inertial attitudes (i.e., nose-sun, tail-sun), the IMUs can be compensated such that the drift rates are on the order of  $10^{-3}$  deg/hr. The .02 deg/hr rule is still a good guideline to follow if the attitudes are constantly changing. But if not, then with good, consistent measurements, the drift can be virtually eliminated by updating the bias compensation terms.

#### C. Recommendations for Subsequent Flights

1. LCC Limit Changes - None.
2. Flight Rule Changes - None.
3. SMS Changes - None.
4. Console Procedure Changes - None.
5. Data Retrieval Adequacy - The hardcopy system continues to be a thorn in our side. The copies are at best difficult to read and at worst indistinguishable.



## MSBLS

### A. Performance

Performance evaluation during the self-test portion of the FCS check-out showed no bias errors as all data fell within the specified self-test values. The following table provides the actual self-test values and the corresponding self-test limits.

MSBLS (Sn)		1(8/12)	2(20/6)	3(21/19)
+Az(deg)	Actual	3.00	3.00	3.00
	Limit	+3.00±0.1		
-Az(deg)	Actual	-3.00	-3.00	-3.00
	Limit	-3.00±0.1		
Range (nm)	Actual	15.13	15.13	15.13
	Limit	15.2±0.2		
Elevation (deg)	Actual	6.00	6.00	6.00
	Limit	6.0±0.1		

During the entry phase, elevation began locking on at about 15.7nm (based on TACAN data) with an elevation angle of 29.5°. All MLS were locked on in range by 13.7nm and azimuth by 13.3nm. Lock-on occurred approximately 0.5 nm sooner than on STS-1 and STS-2. Once locked on solidly, MLS data was incorporated into NAV at approximately 11 nm in range (89:16:03:07 GMT).

The transient loss of lock occurring on the first two flights was not as apparent on STS-3; There appeared to be a very stable lock-on condition throughout the entry phase.

B. Lessons Learned: None

C. Recommendations

1. LCC Limit Changes: NONE
2. Flight Rules Changes: NONE
3. SMS/Model Changes: NONE
4. Console/Mcc procedure changes: NONE
5. Data Retrieval System: Adequate for MLS post mission evaluation.

## OMS TVC

### A. Performance

The first OMS TVC event of importance was the prelaunch gimbal check, for this flight performed at 81:07:42:27 GMT, 8H 18M 33S before launch. The strip chart recorders are the only source of data in OPS 9 for the drive check rates and, unfortunately, it was this time that marked the beginning of endless problems with the recorders for the entire mission. The drive rates were indeterminant from the real time data and had to be calculated from playback.

When the playback data was finally obtained the drive rates were calculated and all, extend and retract, were found to be very close to 5 deg/sec, passing the LCC with no problems. The right pitch actuator was a new one of the modified type installed Jan 28, 1982 when the old actuator failed a drive check performed Jan 25, 1982.

As a result of the decision to launch with TVC powered off and also some funnies generated by changing the RM threshold and fail counter, it was decided a week before launch that the engines could not be more than  $.4^\circ$  (deadzone) from the OPS 1 stow positions for launch to protect against engine movement exceeding the  $.7^\circ$  threshold and powering up the TVC, possibly in secondary. This was a real time call accomplished via a TPC readout in hexadecimal of the position parameters obtained from DFE following the gimbal check. This information revealed that the left yaw position exceeded the  $.4^\circ$  deadzone and the call was made at the Cape to use the ramp function via the LPS to drive back to the stow position. It did not return to the stow position after the gimbal check due to primary-secondary channel interaction. The ramp function was performed at 81:10:25 driving only the left yaw actuator to its stow position & making OMS TVC go for launch.

#### Phase I - Ascent

With TVC powered off, the no-back device in the actuators was relied upon to hold the engine bells in position until MM 104, which is what they were designed for. However, since this was the first flight with no TVC power it had not been confirmed whether they could do the job or not. Ultimately Phase I (MM 101-103) was nominal and there is now great faith in the No-back (seeing is believing).

#### OMS 1

Moding to 104 occurred at 81:16:09:02 GMT, 96 seconds before OMS1, putting the engines at their I-Loaded trim positions. At ignition, 81:16:10:33 GMT, the left & right pitch are commanded down, left pitch to  $1.24^\circ$  from zero and right pitch  $3.25^\circ$  from zero, to take out a plus roll rate of  $30/s$ . However, the MPS dump also starts at ignition so that 4 seconds after this initial maneuver the left pitch is commanded down to counteract the imposed minus roll and the right yaw is commanded out to counteract the minus yaw followed by the right pitch going down to reverse the whole procedure. This is a familiar event after being viewed on STS-1&2 and is caused by the MPS LH2 dump out the port side above the wing starting at 960 lbs and decreasing to a negligible amount in 12 sec.



Its signature is characterized by a minus roll from plume impingement on the wing and a minus yaw in the direction of the thrust vector. After this the burn was nominal lasting 94 seconds, achieving a  $\Delta V$  total of 157.8 ft/sec.

The post OMS 1 gimbal check was performed at 81:16:18:00 GMT and revealed no problems. The recorders were functional and the drive rates were determined to be nominal.

#### OMS 2

The OMS 2 burn was executed at 81:16:40:50 GMT approximately 30 minutes after OMS 1. It was a nominal burn, duration time 89 seconds and a total  $\Delta V$  of 150 ft/sec. The post OMS 2 gimbal check was also nominal.

#### OPS 2 Burn & Gimbal Check

This burn satisfied DTO 344 OMS ENGINE PERFORMANCE the purpose of which was to demonstrate the capability of an OMS engine to restart under zero-g, hard vacuum, worst case engine conditions. The attitude was nose-to-sun and the requirements were a 2.1 second LOMS burn followed by a 240 second coast period and then a LOMS restart and burn for 10 seconds.

The trim positions for the left engine were pitch  $.1^\circ$  and yaw  $4.67^\circ$  which is thru the c.g. The right engine remained in its post OMS 2 trim configurations. The first part of the DTO occurred at 86:22:00 GMT and lasted 2 seconds. The second part was at 86:22:04:04 and lasted 14 seconds. Control was good; attitude errors were less than  $1^\circ$  and except for a low sample rate on the data because it was OPS 2 everything was nominal. There was a gimbal check prior to the OPS 2 burn and one immediately following, both of which showed good drive rates.

#### Deorbit Gimbal Checks

There were two deorbit gimbal checks as a result of the last minute decision to delay entry one day. The first was at 88:17:43:32 GMT approximately ten minutes before the decision to delay and forty minutes before the burn was scheduled. It was done at Bermuda AOS so that it could be seen real time. The second one was done at 89:14:16, an hour before the burn, at Buckhorn AOS. Both gimbal checks showed nominal performance.

#### Deorbit Burn

The deorbit burn was at 89:15:13:30 at YAR and the crew reported it went well. Duration time was 2M35S with minus residuals.  $\Delta V$  total was approximately 253ft/sec.

1. Anomalies - no anomalies were noted

2. Comparison of STS-1,2,&3

The orbiter flew with a new actuator this mission as a result of a test done at KSC Jan 25, 1982 when the right pitch actuator drove at a rate below spec. The new actuator is a modified version with three designs implemented.

The actuators were not intended to be replaced until STS-5. The actuator replaced had caused problems on STS-2 on which it had been a replacement for the original on STS-1. On those two flights the problem had been diagnosed to be the clearance between the rotor & stator being too small and causing friction. This problem did not manifest itself on this flight and the hardware changes will be implemented in STS-5 as scheduled.

There were six gimbal checks on this flight (twice as many as STS-1&2) due to the fuel cell problem on STS-2 for which we were very power-conscious and the extra gimbal check as a result of delaying entry one day.

All the gimbal checks were nominal; all the burns achieved their targets.

B. Lessons Learned - none

C. Recommendations

1. LCC LIMIT CHANGES - The range for the OMS stow position in the Launch Commit Criteria (min and max of redline Flt Control Sec. 6.9.10) needs to be tightened as a result of changing the RM threshold from  $1^{\circ}$  to  $.7^{\circ}$  (CR 39897 OMS RM MM 101-103). This will be done by Jay Vernon in E&D.
2. Flight Rule Changes - none
3. SMS Parameter/Model Changes - none
4. Console or MCC Procedure Changes - none



## RADAR ALTIMETER

### A. Performance

Performance evaluation of the RAs during the FCS checkout showed no bias errors as all data fell within the specified self-test limits of 1000 ft  $\pm$  100 ft. The actual self-test values seen were 1017 ft for RA 1 (S/N5) and 1009 ft for RA 2 (S/N 11).

During the entry phase, RA 2 locked on above 5000 ft in altitude (5240 ft) similar to STS-1. RA 1 locked on considerably later at an altitude of 4425 ft. Once acquired, both altimeters remained valid and locked on throughout landing. Contrary to STS-1, they never lost lock when the nosegear came down at 89:16:04:41 GMT. During that period, until touchdown, the data did not indicate any interference with the gear.

### B. Lessons Learned

Apparently the modifications made to the RAs flown on this flight alleviated the problem of the interference from the nosegear.

Having site coverage during Blackout, the RAs were seen to be locked on with an average output reading of 4.3 ft (RA 1) and 5.4 ft (RA2). It is believed that this may have been caused by the RAs locking onto the plasma generated by the heat of the vehicle during re-entry.

### C. Recommendations:

1. LCC Limit Changes: NONE
2. Flight Rules Changes: NONE
3. SMS/Model Changes: NONE
4. Console/MCC procedure changes: NONE
5. Data Retrieval System: Adequate for RA post mission evaluation.

## Orbiter Rate Gyro System (RGA)

### A. Performance

The ORBITER RGA performance was nominal throughout the mission. The data was nominal and no SMRD talkbacks were noted. The RGA data from the OPS 8 sensor self test satisfied the bias, BITE, and limit test requirements in the PDP, section 3, and in the SODB, volume 1, table 3.4.5.1-2. The same RGA 1, 2, 3, and 4 (S/N-14, 15, 16, 17 respectively) have flown on STS 1, 2 & 3.

#### STS-3 OPS 8 RGA SELF TEST DATA

RGA	ROLL	LIMITS	PITCH	LIMITS	YAW	LIMITS
	BIAS		BIAS		BIAS	
1	0.00	0.00±0.35	-0.04	0.00±0.19	0.00	0.00±0.19
2	0.00	0.00±0.35	0.00	0.00±0.19	-0.04	0.00±0.19
3	-0.08	0.00±0.35	0.00	0.00±0.19	0.00	0.00±0.19
4	-0.08	0.00±0.35	-0.04	0.00±0.19	-0.04	0.00±0.19

RGA HIGH TEST	ROLL	LIMITS	PITCH	LIMITS	YAW	LIMITS
	DATA		DATA		DATA	
1	20.16	+20.0±1.12	10.08	+10.0±0.56	10.16	+10.0±0.56
2	20.08	+20.0±1.12	10.08	+10.0±0.56	10.12	+10.0±0.56
3	20.00	+20.0±1.12	10.04	+10.0±0.56	9.96	+10.0±0.56
4	19.76	+20.0±1.12	9.96	+10.0±0.56	9.92	+10.0±0.56

RGA LOW TEST						
	ROLL	LIMITS	PITCH	LIMITS	YAW	LIMITS
DATA	DATA		DATA			
1	-19.84	-20.0±1.12	-10.20	-10.0±0.56	-10.16	-10.0±0.56
2	-19.92	-20.0±1.12	-10.12	-10.0±0.56	-10.16	-10.0±0.56
3	-20.00	-20.0±1.12	-10.08	-10.0±0.56	-10.04	-10.0±0.56
4	-20.08	-20.0±1.12	-10.04	-10.0±0.56	-10.04	-10.0±0.56

#### 1. Analysis of problems

No problems were noted

#### 2. STS-2 & STS-3 data comparison

The STS-3 ORBITER RGA performance and data were comparable to STS-2

### B. Lessons Learned

There are no recommendations to enhance vehicle or ground systems operations.

### C. Recommendations for Subsequent Activities

1. LCC Limit changes: No limit changes recommended.
2. Flight Rules changes: No flight rule changes required.
3. SMS Parameter/Model changes: RGA motor failure (NO SPIN) capability to be added to OPS 8, effective STS-7.
4. Console or MCC procedure changes: No new console or MCC procedure required.
5. Data Retrieval Adequacy: Data retrieval was adequate and timely.



## SRB RATE GYROS (SRB RGA)

### A. Performance

The SRB RGA performance during SRB first stage (102) was nominal. The data was nominal and no SMRD talkbacks were noted.

#### 1. Analysis of Problems:

During STS-3 dry CDDT at KSC on 2/19/82, the LEFT SRB RGA #3 yaw gyro failed to reach sync speed (SMRD flag displayed) during power up at T-02H 00M. The RGA S/N 43 was replaced with S/N-38. The RGA S/N 43 was returned to Northrup where the failure was isolated to a broken power lead at the Gyro Motor. The RGA S/N 38 is the first SRB RGA to be reused. It was the STS-1 LEFT SRB RGA #3.

#### 2. STS-2 & STS-3 Data Comparison:

STS-3 SRB RGA performance was Comparable to STS-2.

### B. Lessons Learned

System performance was nominal, requiring no change in system operations.

### C. Recommendations for Subsequent Activities

1. LCC Limit Changes: NONE
2. Flight Rules Changes: NONE
3. SMS Parameter/Model Changes: NONE
4. Console or MCC Procedure Changes: NONE
5. Data Retrieval: Adequate

## STAR TRACKERS

### A. PERFORMANCE

The -Y and -Z Star Trackers (ST) performed nominally as expected. For the manual alignment executed at 0/10:34:20, stars 49 acquired by the -Z ST and 60 acquired by the -Y ST were used. Star 60, ENIF is the dimmest star in the nav star catalog and was positioned  $30^\circ$  from the sun. The -Y ST acquired momentarily then loss acquisition for a while only to reacquire again. The ST specification dictates that the ST will track the dimmest star  $30^\circ$  away from the sun. From a performance standpoint then the ST was acquiring under worst case conditions and errors for all alignments did not exceed .02 deg. Table 1 shows ST related data that was used for all IMU alignments and corresponding attitudes.

Figure 1 shows temperature sensor location (view H-H) in the IMU/Star Tracker cavity. The colored in squares represent those measurements that were available on TLM. Figures 2,3,4 show temperatures sensed and are plotted with time (MET). The 24 hour thermal test was successful and did not produce any performance degradation. The temperature band startrackers operated in for the entire flight was between  $80^\circ\text{F}$  and  $100^\circ\text{F}$  (see figure 2). Self test was performed and passed successfully.

Target suppress logic inhibited the acquisition of star of opportunity data approximately 67 of the 167 hours of on-orbit time. The 100 hours of non-target suppress operation time produced good star data to execute 6 star of opportunity alignments of the 17 total star aligns. These star of opportunity alignments greatly helped the timeline and propellant, both of which are critical commodities.

Star of opportunity demonstrated that by using the same star pair produced torquing angles that were consistent and a true measure of drift. Different star pairs generated torquing angles that were inconsistent due to gimbal position errors. A good example of the same star pair evaluation was the nose sun attitude for 73 hours, which produce consistent torquing angles and accurate drift measurements. The variations of torquing angles between same star pairs and different star pairs has also been observed in long duration sims. See Table 1 for data.

#### 1. ANOMALIES

Both the -Z and -Y ST revealed hardware bites again for STS-3. Ref "STS-2 GNC Post Flight Report", pages 21.2, 21.3 for mechanization of the logic that drives each bite. The following is a summary of the bites that occurred each flight day.



FLIGHT DAY	-Z STAR TRACKER				-Y STAR TRACKER			
FLT DAY 1	-	-	6	2	-	-	-	-
FLT DAY 2	-	-	16	8	-	-	-	-
FLT DAY 3	-	-	13	4	-	-	-	-
FLT DAY 4	-	-	6	1	1	-	-	-
FLT DAY 5	1	-	10	3	-	-	-	-
FLT DAY 6	-	1	9	5	1	-	-	-
FLT DAY 7	-	-	9	4	-	-	3	-
FLT DAY 8	-	-	-	6	-	-	-	-
ENTRY DAY	-	-	-	-	-	-	-	-
	BIT COUNT ERROR	PARITY ERROR	MANCHESTER INVALID	TRANSMISSION WD FAIL	BIT COUNT ERROR	PARITY ERROR	MANCHESTER INVALID	TRANSMISSION WD FAIL

These bites were observed when data was available, thus the above data lacks the occurrences during Los. The presence of these bites however did not affect system performance. A recommendation was made post STS-2 to suppress the "G22 STRK" message. This message was driven by the presence of these bites. A software change was made thereby inhibiting the DPS fault pages to be filled with ST fault summary messages.

## 2. COMPARISON OF STS-2 AND STS-3

Star of opportunity was the biggest difference between STS-2 and STS-3. The auto ST Mode (Item 3,4) acquired acceptable star pairs to align the IMU's thereby saving time and consumables. STS-3 demonstrated that star of opportunity proved itself to be a very valuable capability.

## B. LESSONS LEARNED

When the crew executes an ops transition or an ops mode recall spec's 021 and 022 cease processing. This means that star table activity is inhibited and torquing angle data is not displayed. Without this data, star of opportunity data cannot be assessed. To relieve this condition all the crew has to do is mode the star trackers to star track (Item 3,4) on spec 022 and call up spec 021 and resume. These procedures have been implemented in the FDF for STS-4.

## C. RECOMMENDATIONS

1. There are no launch commit criteria violations with the star trackers since they are not required for launch.
2. Flight Rule changes - The present rule dictate that at least one star tracker

will be powered for the entire flight. A change was made to have both star trackers (-Y,-Z) powered for the entire flight to accommodate star of opportunity and a real time decision would be made to power off either star tracker should the on-orbit attitude prove unfavorable for stars of opportunity.

3. Logic should be added to the star tracker math model in the sms to simulate target suppress. This will give a real world environment during star tracker operations, since the fix is not planned until release 19 software. The model community has been informed of this request. Star tracker door open times in the SMS should be 5 seconds to match the real world.
4. Console or MCC procedures changes - none
5. The data retrieval system was adequate for post flight analysis.







TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	SDD/MAN (TORQUE=*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
0:16:03:00	-0.02	-0.02	-0.08	-0.26	.05	-0.01	-0.01	.05	-0.18	STARS 36 & 12 ANG DIFF 92.9 $\Delta t = 18 \text{ MIN}$	500	-Y	TAIL SUN	
0:16:52:00	.00	-0.04	-0.15	-0.29	.01	.08	.08	.09	-0.23	STARS 45 & 39 ANG DIFF 73.2 $\Delta t = 18 \text{ MIN}$	500	-Y	TAIL SUN	
0:19:02:00	-0.02	-0.02	-0.16	-0.39	.03	.01	.01	.10	-0.27	STARS 36 & 12 ANG DIFF 92.9 $\Delta t = 18 \text{ MIN}$	500	-Y	TAIL SUN	
0:19:53:00	.00	-0.05	-0.22	-0.42	.00	.01	.01	.13	-0.33	STARS 45 & 39 ANG DIFF 73.2 $\Delta t = 18 \text{ MIN}$	500	-Y	TAIL SUN	
0:20:36:00	-0.01	-0.03	-0.20	-0.45	.04	.03	.03	.12	-0.32	STARS 36 & 12 ANG DIFF 92.9 $\Delta t = 24 \text{ MIN}$	500	-Y	TAIL SUN	
0:21:26:00	-0.02	-0.06	-0.26	-0.50	-0.02	.10	.10	.14	-0.35	STARS 49 & 39 ANG DIFF 82.6 $\Delta t = \phi$	500		TAIL SUN	
0:22:01:40	.02	-0.03	-0.29	-0.44	.00	.10	.10	.19	-0.33	STARS & ANG DIFF _____ $\Delta t =$ _____	M A N * K N *		TAIL SUN	
0:22:33:00	.00	-0.02	.02	-0.06	.02	.02	.02	.01	-0.06	STARS 45 & 35 ANG DIFF 116.6 $\Delta t = 24 \text{ MIN}$	500		TAIL SUN	
0:22:51:00	-0.01	-0.02	.00	-0.10	-0.01	.03	.03	.00	-0.07	STARS 39 & 45 ANG DIFF 73.2 $\Delta t = 18 \text{ MIN}$	500	-Y	TAIL SUN	
0:23:06:00	-0.03	-0.02	.02	-0.12	.02	-0.04	-0.04	-0.01	-0.08	STARS 12 & 35 ANG DIFF 100.7 $\Delta t = 60 \text{ MIN}$	500	-Y	TAIL SUN	
0:23:32:00	-0.03	.00	.03	-0.12	.03	-0.05	-0.05	-0.01	-0.06	STARS 36 & 12 ANG DIFF 92.9 $\Delta t = 24 \text{ MIN}$	500	-Y	TAIL SUN	



TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	SDD/MAN (TORQUE=*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
1:03:57:00	.02	.00	.03	-.15	.02	-.02	.01	.00	-.07	STARS 36 & 12 ANG DIFF 92.9 Δt = 24 MIN	505	-Y	TAIL SUN	
1:04:46:00	.01	-.03	-.01	-.17	-.01	.08	-.02	.02	-.10	STARS 39 & 45 ANG DIFF 73.2 Δt = 18 MIN	505	-Y	TAIL SUN	
1:05:30:00	-.01	.01	.03	-.17	.02	.00	.00	.00	-.08	STARS 36 & 12 ANG DIFF 92.9 Δt = 24 MIN	505	-Y	TAIL SUN	
1:06:17:00	.01	-.02	.00	-.19	-.02	.09	-.03	.01	-.10	STARS 39 & 45 ANG DIFF 73.2 Δt = 18 MIN	505	-Y	TAIL SUN	
1:06:58:00	.00	.01	.04	-.19	.02	.02	.00	.00	-.09	STARS 36 & 12 ANG DIFF 92.9 Δt = 24 MIN	505	-Y	TAIL SUN	
1:08:27:00	.00	.03	.03	-.19	.01	.03	.00	.01	-.08	STARS 36 & 12 ANG DIFF 92.9 Δt = 24 MIN	505	-Y	TAIL SUN	
1:09:16:00	.03	.00	.00	-.21	-.02	.12	-.03	.03	-.10	STARS 39 & 45 ANG DIFF 73.2 Δt = 18 MIN	505	-Y	TAIL SUN	
1:10:14:00	.00	.00	.00	-.20	-.04	.08	-.03	-.01	-.07	ALIGN IMU 2 & 3 TO 1 IMU-TO-IMU ALIGN IN LIEU OF STAR ALIGN.			PTC	
1:22:00:00	.22	.12	.15	-.14	-.01	-.12	.01	.19	-.34	STARS 45 & 14 ANG DIFF 57.6 Δt = 18 MIN	505	-Y	NOSE SUN	
1:22:30:00	.23	.12	.16	-.17	.00	-.10	.01	.17	-.36	STARS 14 & 18 ANG DIFF 93.3 Δt = 54 MIN	505		NOSE SUN	.02
1:23:21:00	.01	.00	-.02	-.01	-.02	.03	-.03	.04	-.05	STARS 14 & 36 ANG DIFF 73.2 Δt = 12 MIN	505	-Y	NOSE SUN	



TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	500/MAN (TORQUE=*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
2:05:57:00	.13	.13	.04	-.06	.03	.09	.01	.06	-.35	STARS 45 & 24 ANG DIFF 83.1 Δt = 0	005		NOSE SUN	
2:08:02:00	.14	.18	.07	-.07	.05	.16	-.01	.10	-.42	STARS 36 & 12 ANG DIFF 92.9 Δt = 12 MIN	005	-Y	NOSE SUN	
2:09:13:00	.15	.21	.07	-.09	.05	.11	.03	.06	-.47	STARS 39 & 45 ANG DIFF 73.7 Δt = 54 MIN	005	-Y	NOSE SUN	
2:09:30:00	.16	.19	.03	-.09	.05	.19	-.07	.11	-.47	STARS 36 & 12 ANG DIFF 92.9 Δt = 12 MIN	005*	-Y	NOSE SUN	.01
2:10:48:00	.01	.00	.05	-.07	.00	-.05	.03	-.04	.00	STARS 45 & 24 ANG DIFF 83.1 Δt = 0	005		NOSE SUN	
2:12:13:00	.11	.03	.19	-.17	.06	.14	.07	.04	.04	STARS 33 & 13 ANG DIFF 104.2 Δt = 12 MIN	005*	-Z	NOSE SUN	.07
2:21:34:00	.00	-.01	-.07	-.07	-.04	.00	-.01	.00	-.01	STARS 14 & 36 ANG DIFF 73.2 Δt = 12 MIN	005		NOSE SUN	
2:22:40:00	.02	.07	.01	.00	.00	-.03	.03	.01	.01	STARS 23 & 45 ANG DIFF 82.1 Δt = 60 MIN	005	-Y	NOSE SUN	
2:22:57:00	.07	.00	-.03	-.01	-.01	-.05	-.01	.05	.01	STARS 36 & 12 ANG DIFF 92.9 Δt = 12 MIN	008	-Y	NOSE SUN	
3:00:25:00	.01	-.03	.03	-.06	.00	.03	-.01	.03	.00	STARS 36 & 14 ANG DIFF 73.2 Δt = 1.5 HRS	008		NOSE SUN	
3:01:35:00	.00	.03	.08	-.05	.07	.00	.04	.07	.03	STARS 23 & 14 ANG DIFF 132.8 Δt = 1.2 HRS	008	-Y	NOSE SUN	



TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	SDD/MAN (TORQUE=*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
3:02:00:00	.03	.01	.06	-.06	.03	.02	.03	.03	.02		505	-Y	NOSE SUN	
										STARS 23 & 45 ANG DIFF 82.1 $\Delta t = 30 \text{ MIN}$				
3:05:04:00	.05	-.02	.09	-.14	.01	.09	.06	.06	.03		505		NOSE SUN	
										STARS 14 & 36 ANG DIFF 73.2 $\Delta t = 12 \text{ MIN}$				
3:06:21:00	.08	.00	.07	-.13	.04	.15	-.01	.11	.06		505	-Y	NOSE SUN	
										STARS 12 & 36 ANG DIFF 92.9 $\Delta t = 12 \text{ MIN}$				
3:07:35:00	.08	-.01	.13	-.15	.09	.11	.02	.09	.03		505		NOSE SUN	.01
										STARS 34 & 41 ANG DIFF 88.6 $\Delta t = 0$				
3:08:27:00	.00	.03	.02	.00	-.03	-.02	.01	.00	.06		505	-Y	NOSE SUN	
										STARS 23 & 45 ANG DIFF 82.1 $\Delta t = 24 \text{ MIN}$				
3:11:24:00	-.01	.02	.00	-.02	-.03	.04	-.03	.04	.07		505		NOSE SUN	
										STARS 36 & 12 ANG DIFF 92.9 $\Delta t = 12 \text{ MIN}$				
3:12:20:00	.00	.04	.06	-.02	-.01	-.02	.01	.00	.07		505	-Y	NOSE SUN	
										STARS 23 & 45 ANG DIFF 82.1 $\Delta t = 54 \text{ MIN}$				
3:13:38:00	-.01	.05	.06	-.02	.02	.01	.02	.02	.05		505	-Y	NOSE SUN	
										STARS 12 & 39 ANG DIFF 69.1 $\Delta t = 12 \text{ MIN}$				
3:13:57:00	-.01	.03	.05	-.04	.00	.04	-.02	.02	.08		505	-Y	NOSE SUN	
										STARS 36 & 12 ANG DIFF 92.9 $\Delta t = 12 \text{ MIN}$				
3:15:04:00	.00	.04	.09	-.04	.00	-.02	.01	.00	.09		505	-Y	NOSE SUN	
										STARS 23 & 45 ANG DIFF 82.1 $\Delta t = 54 \text{ MIN}$				
3:15:17:00	-.01	.03	.06	-.05	.01	.04	-.02	.03	.09		505	-Y	NOSE SUN	
										STARS 36 & 12 ANG DIFF 92.9 $\Delta t = 12 \text{ MIN}$				



TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	S00/MAN (TORQUE=*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
: : :														
3:18:24:00	.01	.03	.13	-.10	.01	.02	-.02	-.02	.08	STARS 14 & 36 ANG DIFF 73.2 Δt = 12 MIN	005	-Y	NOSE SUN	
3:19:22:00	.00	.06	.15	-.08	.04	-.02	.01	.00	.09	STARS 23 & 45 ANG DIFF 82.1 Δt = 54 MIN	005	-Y	NOSE SUN	
3:19:43:00	.00	.05	.11	-.08	.04	.05	-.02	.04	.09	STARS 36 & 12 ANG DIFF 92.9 Δt = 12 MIN	005	-Y	NOSE SUN	
3:20:51:00	.00	.07	.17	-.08	.06	.07	.03	.00	.09	STARS 23 & 45 ANG DIFF 82.1 Δt = 54 MIN	005	-Y	NOSE SUN	
3:21:09:00	.00	.06	.13	-.09	.05	.05	-.01	.03	.09	STARS 36 & 12 ANG DIFF 92.9 Δt = 12 MIN	005	-Y	NOSE SUN	
3:23:15:00	.01	.05	.18	-.13	.04	-.01	.01	.07	.07	STARS 35 & 45 ANG DIFF 116.6 Δt = 1.8 HRS	005		NOSE SUN	
3:23:46:00	-.01	.06	.17	-.11	.04	-.01	.01	-.01	.08	STARS 45 & 24 ANG DIFF 83.1 Δt = 0	005		NOSE SUN	.02
4:00:10:00	.02	.01	-.03	.01	.01	.06	.03	.05	.07	STARS 36 & 12 ANG DIFF 93.0 Δt = 12 MIN	005		NOSE SUN	
4:01:10:00	.01	.01	.00	.00	.00	-.01	.00	.00	.01	STARS 45 & 24 ANG DIFF 83.1 Δt = 0	005		NOSE SUN	
4:02:35:00	.01	.00	.02	-.03	.01	.02	.00	.00	-.01	STARS 18 & 14 ANG DIFF 93.3 Δt = 42 MIN	005		NOSE SUN	
4:02:50:00	.02	.04	.02	.00	.02	-.01	.02	.02	.00	STARS 23 & 45 ANG DIFF 82.2 Δt = 6 MIN	005		NOSE SUN	

3.19.9



TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	SDO/MAN (TORQUE*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
: : :	.00	.01	.03	-.04	.01	.01	.00	.00	.01	-.01			NOSE SUN	
4:04:04:00	.00	.01	.03	-.04	.01	.01	.00	.00	.01	-.01			NOSE SUN	
4:04:40:00	.01	.03	-.01	-.02	.01	.06	-.01	.04	.01	-.01			NOSE SUN	
4:06:10:00	.01	.04	.03	-.04	.02	.03	.01	.03	.03	-.02			NOSE SUN	
4:07:35:00	.01	.05	-.01	-.03	.01	.07	-.02	.05	.01	.01			NOSE SUN	
4:09:06:00	.03	.05	.05	-.06	.05	.04	-.03	.04	.04	.02			NOSE SUN	
4:09:24:00	.03	.08	.04	.01	.06	.01	-.03	.04	.01	-.01			NOSE SUN	
4:09:57:00	.02	.10	.04	.03	.07	-.03	.01	.04	.01	.08			NOSE SUN	
4:09:59:00	.03	.08	.04	.03	.07	-.03	.01	.05	.01	.10			NOSE SUN	
4:10:02:00	.02	.07	.07	-.01	.07	-.03	.01	.04	.01	.09			NOSE SUN	
4:10:03:00	.02	.08	.06	.00	.07	-.03	.01	.04	.01	.09			NOSE SUN	
4:10:20:00	.04	.07	.05	.00	.06	.04	-.01	.05	.01	.09			NOSE SUN	

3.19.10



TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	S00/MAN (TORQUE*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
4:10:34:00	.02	.06	.00	-.03	.01	.06	-.04	.09	.10	STARS 36 & 12 ANG DIFF 92.9 Δt = 12 MIN	000		NOSE SUN	
4:11:45:00	.02	.09	.06	-.04	.03	-.02	.01	.04	.10	STARS 23 & 45 ANG DIFF 82.1 Δt = 54 MIN	000	-Y	NOSE SUN	
4:12:15:00	.01	.05	.04	-.07	-.01	.03	-.03	.05	.09	STARS 14 & 36 ANG DIFF 73.2 Δt = 12 MIN	000	-Y	NOSE SUN	
4:19:20:00	.01	.09	.09	-.07	.04	-.01	.00	.04	.08	STARS 33 & 14 ANG DIFF 98.3 Δt = 7.1 HRS	000		NOSE SUN	
4:19:43:00	.02	.10	.07	-.13	-.01	-.04	.00	.05	.08	STARS 33 & 14 ANG DIFF 98.3 Δt = 24 MIN	000		NOSE SUN	
4:20:36:00	.01	.10	.08	-.13	.00	-.06	.02	.05	.08	STARS 24 & 45 ANG DIFF 83.1 Δt = 48 MIN	000	-Y	NOSE SUN	.01
4:22:58:00	.02	.00	-.01	-.03	-.04	.00	-.03	.01	.00	STARS 36 & 14 ANG DIFF 73.2 Δt = 6 MIN	000		NOSE SUN	
5:00:30:00	.03	.01	.02	.04	-.01	-.01	-.01	.01	-.02	STARS 33 & 14 ANG DIFF 98.3 Δt = 1.9 HRS	000		NOSE SUN	
5:00:56:00	.03	.02	.00	-.05	-.03	-.05	.01	.03	-.01	STARS 45 & 24 ANG DIFF 83.1 Δt = 0	000		NOSE SUN	
5:04:34:00	.05	.02	.01	-.10	-.07	-.06	-.01	.04	.00	STARS 14 & 36 ANG DIFF 73.2 Δt = 6 MIN	000		TOP SUN	
5:06:32:00	.07	.03	.04	-.11	-.03	-.08	.00	.04	.03	STARS 39 & 45 ANG DIFF 73.3 Δt = 1 HR 54 MIN	000	-Z	TOP SUN	

3.19.11



TABLE 1 Cont.

PET	IMU #1			IMU #2			IMU #3			REMARKS	500/MAN (TORQUE*)	TARGET SUPPRESS	ATTITUDE	ANG ERR
	X	Y	Z	X	Y	Z	X	Y	Z					
: : :														
5:09:03:12	.11	.04	.10	-.17	-.02	-.11	-.03	.09	.17	STARS 48 & 49 ANG DIFF 83.9 Δt = 0	MAN*		TOP SUN	.01
5:21:02:11	.01	.05	.27	-.21	-.07	-.33	-.13	.05	.49	STARS 29 & 22 ANG DIFF 83.8 Δt = 0	MAN*		TOP SUN	.01
6:08:57:00	.03	.06	.07	-.07	.15	-.01	-.05	.08	-.01	STARS 49 & 60 ANG DIFF 84.1 Δt = 0	MAN*		TOP SUN	.02
6:18:48:00	.09	.11	-.09	.01	.19	.09	.21	.12	-.28	STARS 31 & 12 ANG DIFF 86.0 Δt = 0	MAN*		PTC	.01
7:00:40:00	-.02	.00	-.14	-.04	.00	.11	-.05	.08	-.02	STARS 16 & 23 ANG DIFF 82.9 Δt = 0	MAN*		PTC	
7:04:00:00	-.01	-.01	-.10	-.05	.00	.06	-.07	.06	.00	STARS 43 & 35 ANG DIFF 107.9 Δt = 6 MIN	500		PTC	
7:04:24:00	-.02	-.02	-.08	-.10	.03	.05	-.08	.02	-.02	STARS 23 & 19 ANG DIFF 97.9 Δt = 6 MIN	500		PTC	
7:05:54:00	-.01	-.01	-.16	-.07	-.01	.09	-.09	.09	-.01	STARS 43 & 25 ANG DIFF 107.9 Δt = 36 MIN	500*		PTC	.02
7:17:24:45	.05	.09	-.28	-.12	-.05	.19	-.07	.12	-.04	STARS 44 & 48 ANG DIFF 83.9 Δt = 0	MAN*		TAIL SUN	
7:21:21:00	-.03	.05	-.03	.03	.02	-.05	-.01	.07	.03	STARS 16 & 23 ANG DIFF 82.9 Δt = 0	MAN*		TOP SUN	.02
7:21:27:00	-.01	-.01	.00	-.02	.02	-.01	.02	-.04	.00	STARS 50 & 31 ANG DIFF 91.9 Δt = 0	MAN verif		TOP SUN	

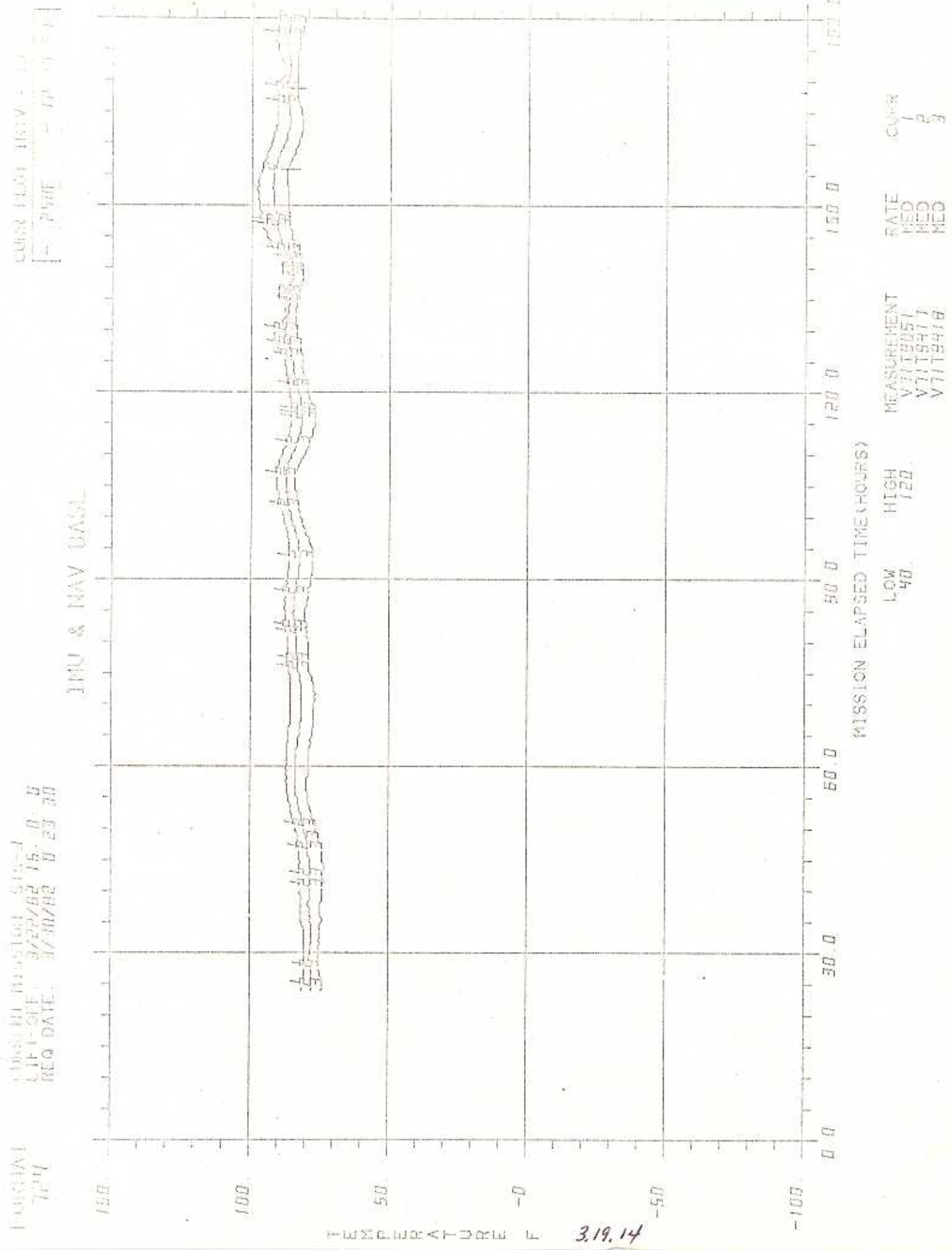
21.19.12







FIGURE 2



0306041  
 0306041  
 LIFE-OFF 3/22/82 15.0 0.0  
 REQ DATE 3/30/82 0 23 30

CURR FLIGHT 1181111  
 TIME - 170 00 50

3.19.14

1 ORGVAL  
TEMP

CUMULATIVE MILES 615-3  
LIFT-OFF: 3/22/02 15:00  
REQ DATE: 3/10/02 023 5R

CURR FLGT LINE# 117  
- 2510P - 09 03 5.7

IMU & NAV BASE

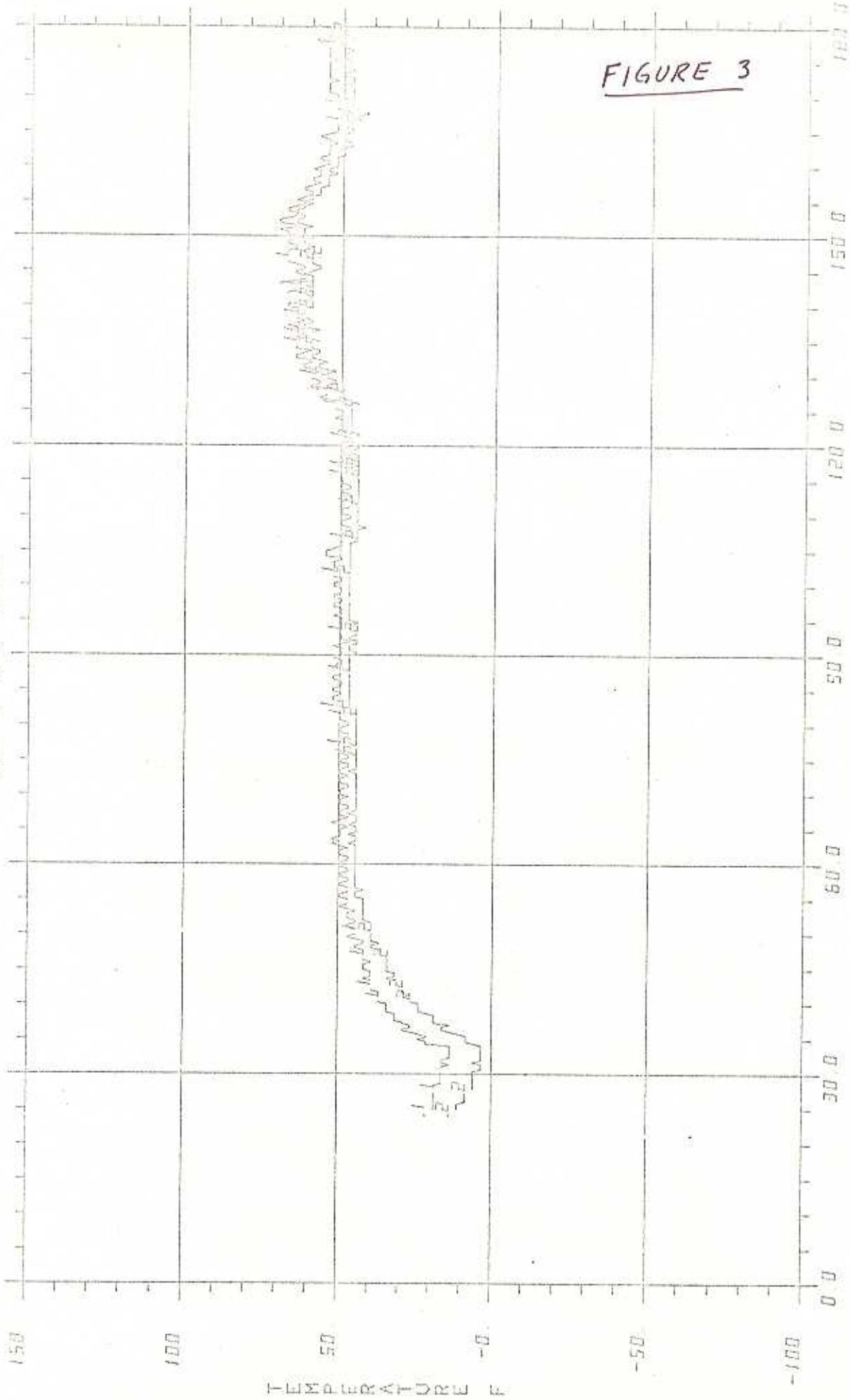


FIGURE 3

MISSION ELAPSED TIME (HOURS)

LOW	HIGH	MEASUREMENT	RATE	CURR
-100	150	V7119005	MED	1
		V7119420	MED	2

3,19,15

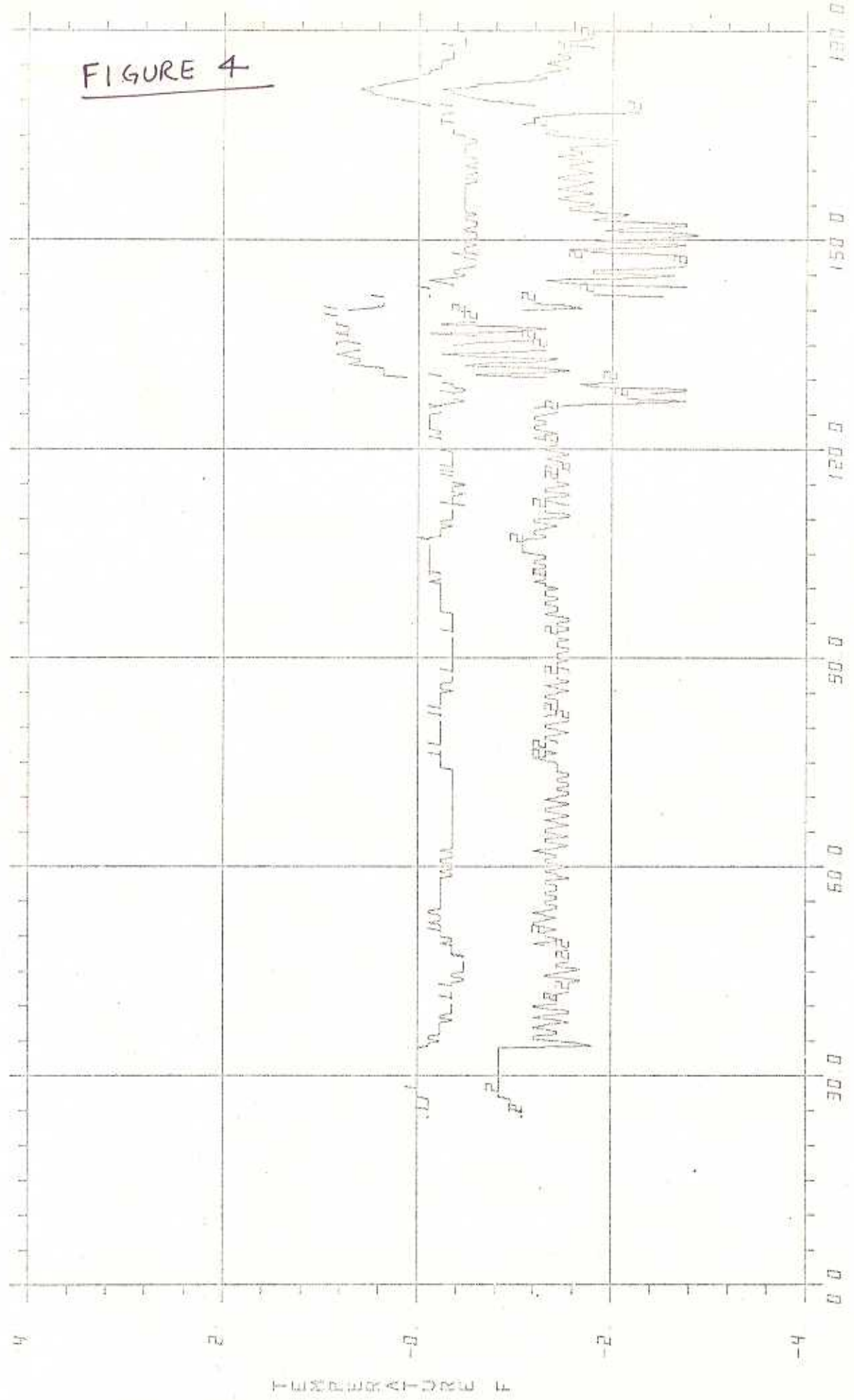


FORMAT  
150.

CURRENT MISSION: STS-3  
LIFT-OFF: 3/22/82 15:01:00  
REQ DATE: 3/30/82 0:19:44

CURR PLOT (MIN) = 10  
- BF - 12.57 53

STAR TRKR DELTA TEMP



MEASUREMENT  
VTI19854  
VTI19855

LOW HIGH

RATE  
MED  
MED

CURR  
1  
2

3,19,16

## SWITCHES

### A. Performance

GNC switch performance during STS-3 was nominal. There were no hardware failures and no reported anomalies.

### B. Lessons Learned - NONE

### C. Recommendations

1. LCC Limit changes - NONE
2. Flight Rule changes - NONE
3. SMS changes - recommend SMS provide capability to fail individual switch contacts.
4. Console changes - NONE
5. Data Retrieval - NONE



## TACAN

- A. Performance - With Entry to Northrup presenting a new trajectory and terrain, in comparison with the Edwards entries on STS-1 and STS-2, it was difficult to predict expected TACAN performance. However, with numerous mountain ranges along the groundtrack we did anticipate a problem with erratic bearing data due to reflected signals as was evident during STS-1. Unlike the two previous missions, blackout exit occurred at Mach=14, some 4.5 minutes prior to initial solid TACAN reception. (TACAN Range data is actually prohibited above Mach=10 via Post Selection filtering).

TACAN	PARAMETER	LOCK-ON ALT.	ANTENNA	REMARKS
#2	Bearing	149,500'	Lower	Approx. Mach=9
#3	"	149,500'	Lower	1 sec. after Brg. #2
#1	"	149,000'	Upper	7 " " "
#2	Range	148,000'	Lower	16 " " "
#3	"	143,000'	Lower	35 " " "
#1	"	134,000'	Upper	70 " " "

On previous missions Range lock-ons occurred within seconds of one another. A possible reason for the late lock-on of Range #3, and especially Range #1, may be the vehicle attitude during this period. A positive vehicle roll existed, which would be unfavorable for TACAN's #3 and #1, upper or lower antennas, due to polarization effects; the only antenna that would benefit from a positive roll is #2 lower, as its polarization angle is 30° CCW at zero vehicle roll. Bearing #1 actually lost lock (after 55 seconds of solid lock-on) when TACAN #1 switched to its lower antennas, due to a short period of no-range lock. At that point the lower antenna #1 was approaching a 90° polarization angle (vehicle roll reached +50°).

Following 3 minutes of solid bearing data (from 3 units) bearing #2 began to exhibit sporadic 40° glitches. At approximately 102,000 ft. (vehicle roll angle of -47°) Brg #2 output 14 consecutive data points that exceeded the 6° RM limit, with an RM failure correctly declared after the tenth cycle. The vehicle attitude represented a highly unfavorable condition for the lower antenna #2 polarization angle, making TACAN #2 vulnerable to 40° glitches. (As a matter of fact, Range #2 eventually lost lock and TACAN #2 was switched to its upper antenna). However, the first 7 outputs were not of the 40° category but rather random values. This suggests a possible interference received from the ground station via a reflected signal off of local mountain ranges.



During STS-1, bearing #2 was failed in exactly the same manner, while on its lower antenna, and at approximately the same vehicle attitude. On the other hand, STS-2 TACAN's were all selected to their upper antennas (due to a late power-on condition). As the upper antennas appear to be somewhat less sensitive to signal reflections off of the terrain, it has been suggested that the crew manually select the upper antennas (at least for LRU's #1 and #2). However, that would sacrifice our auto-antenna switching scheme and thereby compromise the Range parameters in attempting to eliminate a bearing annoyance. Due to the extreme down-weighting of TACAN bearing data in the Nav equations, it is unlikely this solution will be employed.

For the remainder of the Entry phase all TACAN's exhibited good bearing data, with only sporadic groups of 40° glitches (as many as 7 consecutive outputs). An interesting phenomenon occurred at approximately 15K ft. when all 3 TACAN's exhibited the same 40° bearing glitch for 5 overlapping seconds. The Selection Filter output the erroneous value for those 5 seconds; however, the post selection filter inhibited use of the bad data, as it differed from the previously selected data by more than 4.5° (had this difference persisted for 10 seconds, it would have been sent to NAV with a satisfactory Data Good flag, at which time the NAV EDIT function would have to inhibit its use). The vehicle attitude at that point was ~35° position roll and a pitch down of ~12° (just coming off of the HAC).

A CR has been proposed which should minimize the occurrence of bearing failures due to transient glitches (multiple of 40°), by inhibiting FDIR during this recognizable condition. Another proposed CR will inhibit bearing data into RM whenever Range lock-on is lost. These CR's would have avoided the transient bearing failures that occurred on STS-1 and STS-3.

#### OPS 8 SELF-TEST

TACAN	AZIMUTH	RANGE
(LIMITS)	(177.5 to 182.5)	(0.0 to 0.5)
1 s/n 65	179.7	0.00
2 s/n 34	179.5	0.00
3 s/n 64	179.7	0.05

The OPS 8 TACAN Self-Test was performed with no visible problems.

- B. Lessons Learned - DTO #379 "On-Orbit TACAN NAVIGATION" appeared to be highly successful from a hardware standpoint, in as much as numerous TACAN lock-ons occurred around the world. The ability to generate an adequate On-board Nav State is yet to be determined.
- C. Recommendations -
  1. LCC Limit Changes - None
  2. Flight Rules Changes - None



3. SMS Parameter/Model Changes - Integrated MCC Simulators to Northrup were somewhat unrealistic, mainly due to the actual early exit from blackout and subsequent timing of TACAN lock-ons.
4. Console or MCC Procedure Changes - A new TACAN timetag was employed during this mission, as recommended by MPAD personnel (prior to incorporation of a new TACAN timetag algorithm). Our Radar/Range plot indicated an initial Range error at acquisition of approximately 0.2 NM (which is a vast improvement over previous missions). However, this error remained between 0.20 and 0.15 NM for the entire Entry phase, for all units; this would suggest an error in the expected location of the TACAN mobile station (O69X). A preliminary look at on-orbit range data to Northrup suggests a possible station bias (of similar magnitude and direction). If this is substantiated, then the TACAN timetag used for STS-3 could be considered more than adequate, possibly eliminating any need for a TACAN algorithm.
5. Data Retrieval Adequacy - We received excellent MDRF response from the Data Retrieval personnel with regard to Entry data requests (all requested data was received by noon on the day following touchdown).

One minor coordination problem encountered during the mission was that of being notified that our requested playback was in progress (too late), rather than receiving prior warning. In some cases data at the beginning of a playback was missed, requiring a subsequent playback request, which caused some inconveniences. In the same vein, running playbacks during AOS periods essentially wastes the playback effort.

April 1, 1982

## STS-3 ANOMALY LIST-FINAL

ANOMALY	TIME	DESCRIPTION/IMPACT/RESOLUTION	STATUS
FAO-02	01/2122	CDR REPORTED THAT WCS STOPPED WORKING WHILE BEING USED - MOTOR STOPPED RUNNING. NOTED THAT CB ON PANEL ML86B (WCS CONTROLLER/SLINGER MN A) WAS OPEN. WCS SLINGER WON'T OPERATE IN FECS SPEED SELECTION (1600 RPM) BUT DOES OPERATE AT ABOUT 60 RPM IN THE EMESIS SPEED SELECTION (NORMAL IS 250 RPM). SUSPECT USED EMESIS EAG MAY BE CAUGHT ON THE SLINGER TINES WHICH SWEEPS THE DEBRIS SCREEN. PLAN IS TO OPERATE WCS WITH SLINGER AT EMESIS SPEED FOR REMAINDER OF FLIGHT.	CLOSED
FAO-03	04/0212	INTERIOR DAC FILM MAGAZINE END-OF-FILM INDICATOR LIGHT DID NOT ILLUMINATE WHEN CANNISTER WAS EMPTY. NOW USING ANOTHER FILM MAGAZINE.	CLOSED
FAO-C4	05/0651	LEMONADE BEVERAGE CONTAINER FAILURE. CREW REPORTS THAT THIS IS THE THIRD CONTAINER THAT IS BROKEN ON THE TOP LEFT SIDE BELOW THE VALVE. NO FURTHER CREW ACTION.	CLOSED
GNC-01	00/1420	IMU 3 X/Y ACCEL OUTPUT HAD A LARGE JUMP (APPROX 6 - SIGMA) FROM PREVIOUS VALUE. UPLINK OF ACCELERATION BIAS COMPENSATED FOR THIS JUMP.	CLOSED
GNC-02	07/2357	TACAN 2 LOST BEARING. RANGE WAS GOOD.	CLOSED
INCO-01	00/0515	RECEIVED A BITE ON THE DEI PCM RECORDER. SEVERAL TIMES DURING HI-SAMPLE START, THE BITE BIT WENT TO ZERO. (THIS INDICATION HAS BEEN SEEN ON STS-2 AND IS NOT BELIEVED TO BE A PROBLEM).	CLOSED

5.2.7



Statement of problem: Evaluation of high winds aloft on "wave-off" day and landing with a high touchdown velocity, a lateral offset error, and a pitchup during derotation.

Discussion:

Winds aloft: Although the "wave-off" on the seventh day was based on excessive surface winds, the winds aloft were also excessive. It was doubtful that the planned approach geometry with the extreme winds above 25,000 feet would have provided a manageable energy situation. Simulations have been conducted to evaluate procedures and system capability for accommodating various extreme wind conditions. The result is a set of placards that relate the wind magnitude and direction to the direction of the heading alignment turn. This will insure that the resulting trajectory is within the vehicle energy management capability.

Touchdown velocity: The velocity at touchdown was about 225 knots estimated air speed rather than the desired 195 knots. At crew takeover from autoland, the airspeed was 6 knots greater than nominal. Simulations indicate that autoland would have flown the vehicle to touchdown at 201 knots. The planned late takeover from autoland did not provide sufficient time for the pilot to feel the vehicle response. Attempts to make some minor trajectory adjustments resulted in a touchdown sooner than intended at a higher than planned airspeed. Future flight procedures will plan the takeover prior to preflare or let the autoland go to touchdown.

Offset error: The landing offset, some 28 feet to the right of the runway centerline, was a known problem with the MSBLS antenna system and is acceptable for lakebed landings. A hardware modification to the ground antennas will be made prior to STS-5 to eliminate the offset.

Derotation pitchup: This problem was aggravated by the high landing velocity. The derotation after main gear touchdown was allowed to start at too high an airspeed and required the pilot to try to stop it at too low a pitch angle. The rapidly changing elevator trim requirements made it difficult to avoid over-controlling in this situation. The way to avoid it is to concentrate immediately after touchdown on keeping the nose up until the vehicle slows to 180 knots. Flight procedures will be more explicit for STS-4 and the SMS simulation of this situation is being improved to provide better crew training.

Conclusions: The actual "wave-off" was based on excessive surface winds, but a "wave-off" due to excessive winds aloft was also required. The planned late takeover from autoland did not allow the pilot time to get the feel of the vehicle, resulting in a premature touchdown at high speed. The landing offset was a known problem with the MSBLS antenna system and is acceptable for lakebed landings. The pitchup during derotation resulted from starting the pitchover above 180 knots where over-controlling is difficult to avoid once the nose drops below about 3 degrees.

Corrective action: The new wind placards will be adopted for STS-4 and subsequent flights. On future missions, manual takeover from autoland will not be planned between start of preflare and touchdown. MSBLS antennas are being modified prior to STS-5 to eliminate the lateral offset error. Procedures will be more explicit, the SMS updated, and more specific crew training provided in the derotation maneuver, especially for high-speed landings.

APPROVED

*Aaron Cohen*  
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5/24/82  
Date

Effective on subsequent missions: None

Personnel assigned: D. W. Gilbert/EH4; R. J. Ward/WA3

Resolution: CLOSED 5/21/82