

Check

STS-2 GNC POST FLIGHT REPORT

Attached is the GNC STS-2 post flight report. The report is broken into four individual software areas, two significant FTOs, and seventeen 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 becomes a working document as a reference for future system evaluation.

The reports include the analysis, to date, of the known GNC STS-2 anomalies. These are:

- a. COAS light
- b. IMU 3 erratic behavior
- c. IMU redundant rate bite at MECO
- d. Pilot RHC trim switch failure
- e. Star tracker transmission error bite
- f. Star tracker target suppress (STS-1 also)
- g. Spurious jet firing when FCS power cycled in TRANS DAP (STS-1 also)

A major problem noted throughout the reports is the lack of a near real time analysis capability due to the slowness of the data retrieval system. This problem was also encountered in preparation of this post flight report when attempting to obtain super thrift data in a timely manner.

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AERO JET DAP

A. Performance

General- The performance of the AERO JET DAP was evaluated between M8 and HAC intercept by comparing effector and vehicle response to manual RHC inputs and auto guidance commands. Orbiter weight was 204,800lb and Xcg at M3 was 1097.3. No significant asymmetry was noted either in terms of cg or "bent airframe" ($Y_{cg} = -.3in$). Processing time for OI data precluded a thorough evaluation of DAP performance above post blackout AOS. The "Quick Look" report dated 11/21/81 by EX3 however, indicated that no significant changes to DAP performance occurred during blackout. The overall performance of the AERO Jet Dap appeared nearly identical to STS-1. Response to single or multi axis inputs from guidance or RHC manual appeared satisfactory. The only undesirable oscillations and deviations from nominal trajectory appeared to be the result of inappropriate guidance for the existing situation and not poor dap performance. On one occasion DAP commanded the speedbrake open due to an above nominal Q condition while rolling on the HAC. At this particular time the vehicle was below nominal energy and opening the speedbrake aggravated this situation. The second instance was observed on final when auto mode was commanded (See Fig. 1). The DAP set up a low frequency (.05HZ) lightly damped oscillation in the FCS which resulted in a .5g vehicle oscillation. This appeared to be the result of the DAP attempting to satisfy high gain guidance commands since the oscillation was also present in bank angle command. While these were not considered DAP anomalies, in that the DAP was responding as commanded, they are worthy of note. The following paragraphs illustrate some of the transient and steady state responses to command inputs and reconfiguration changes. These examples serve to illuminate the performance of the Aero Jet Dap.

Dynamic Response- The short term (dynamic) performance of the DAP was evaluated by looking at effector and orbiter responses to manual and auto commands issued by guidance and RHCs. Figure 2 and figure 3 are time histories of FCS parameters observed between M8 and HAC intercept. Longitudinal and LAT/DIR responses to manual RHC inputs can best be seen in the HAC acquisition maneuver. LAT/DIR response to auto guidance commands are observed in the YJet firings, aerosurface deflections and body rates during roll reversals 3 and 4. Reversal 1 was completed in CSS to preclude recurrence of the STS-1 lateral oscillation. Reversal 4 clearly shows the rudder participation following its activation at M 3.5. In this case the DAP only fired 3 jets over a shorter time, instead of the 4 used in previous reversals, to establish the I-Loaded 5 °/sec roll rate. The lateral axis also shows the responses to the PTIs. Generally all responses appeared fast and well damped. Jet and aerosurface commands were in all cases appropriate to achieve the I-Loaded values with the steady state rates falling very close to these values. The performance of the DAP as manifested in the dynamic responses of the effectors and body rates to commands appeared satisfactory.

Trim Schedule Tracking - DAP performance in tracking the orbiter trim solution was evaluated by assessing the magnitude of aerosurface trim schedule deviations as well as angle of attack error and bank angle error. Aside from transient errors associated with bank angle command changes, steady state bank angle error never exceeded 5 degrees. Alpha error (steady state) remained less than ± 1 degree at all times. Figure 4 illustrates the body flap schedule. The elevon remained within the 1 degree deadband at all times above M2. The deadband was exceeded on two occasions below M2 as expected from STS1 data. Once at M=1.75 when the body flap saturated the elevon went off schedule -3 degrees. Again at M .86 when the body flap was unable to track the transonic pitching moment change the elevon went off schedule +5 degree. No lateral CG or bent airframe condition was noted and steady average aileron trim was 0 degrees throughout the entry. Figure 5 illustrates the angle of attack profile and the limitations imposed by the flight rules. The only violation of the alpha limits occurred as expected during the POPU maneuver. The trim schedule tracking performance of the DAP, as evidenced by aerosurface trim schedules and trajectory command errors was satisfactory.

Transients associated with Reconfiguration changes and FCS Activation points - DAP performance during RECON changes and FCS activation points was evaluated by arbitrarily selecting five key points in the post blackout trajectory and analyzing the aerosurface and body rate transients associated with these points. Figures 1, 2 and 3 illustrate these checkpoints. No unusual transients were associated with either the speedbrake retraction at M=4 or rudder activation at M-3.5. Roll reversal 4 occurred nearly coincident with TAEM interface but no other significant transients were observed at this checkpoint. YJET deactivation occurred at M-1 and interrupted PTI 7. Figure 1 shows a .05g lateral acceleration (N_y) transient that seems to be associated with this checkpoint. The final checkpoint is also illustrated by figure 1 and occurred when auto was selected on final. A long period oscillation developed which appears to be a result of Guidance-DAP interaction rather than a DAP performance problem. The vehicle was 2.5° off commanded bank angle and 40 psf below QREF at the FCS auto activation point. Although there was a small elevon transient at activation the persistent aerosurface oscillations indicate that the DAP was attempting to follow guidance command. This is not considered to be a DAP performance anomaly. No other significant transients were noted at DAP Recon points.

Flight Rule/Rate limit violations- DAP adherence to the operational limitations as published on pages 8-9 through 8-11 of the Flight Rules was evaluated since these limits exceed the I-Loads. These limits are shown graphically on figures 2, 3 and 5. No violations were observed with the possible exception of PTI-3. This PTI may have exceeded the 5 deg/sec roll rate limitation above M=1.5 by as much as 1.5 deg/sec. This was a transient excursion of less than one second and is not considered significant. DAP adherence to the I-Loaded limits was satisfactory.

B. Lessons Learned -

No unexpected situations were encountered relative to the Aero Jet Dap. A quick look evaluation however is dependant on rapid retrieval

of DELOG and THRIFT data immediately following the flight. The delays encountered by peak processing demands on GSDS degraded the completeness of this evaluation.

C. Recommendations for Subsequent Activities

1. LCC Limit changes: N/A
2. Flight Rule changes: N/A
3. SMS Parameter/Model changes: None, pending more detailed stability derivative analysis
4. Console or MCC Procedure changes: None
5. Data Retrieval Adequacy: The data retrieval system available to flight controllers is too inflexible for effective and timely analysis and reporting. GSDS is not configured under normal ops to provide complete DELOG data through entry for example. DELOG and strip chart recordings were the only data available within one week of the mission. More importantly there is no digital data retrieval system available to flight controllers for data editing and plotting. Cutting and pasting existing SCR traces, and hand plotting DELOG data is costly, time consuming, and inaccurate. Finally, a flexible and effective data base for training and establishment of operational mission rules will demand a more suitable and accessible data storage system.

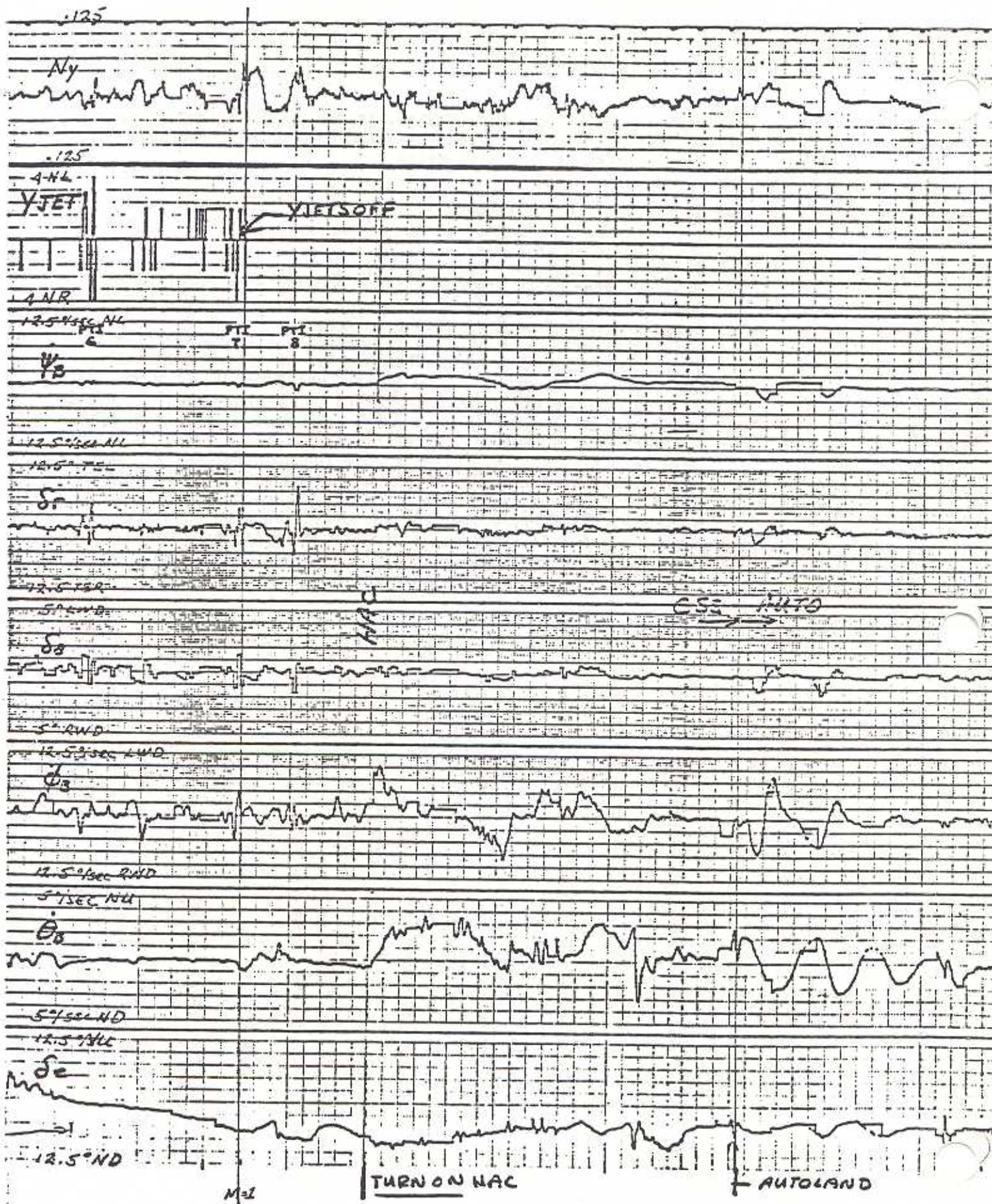


fig 1

1.4

4.1.5

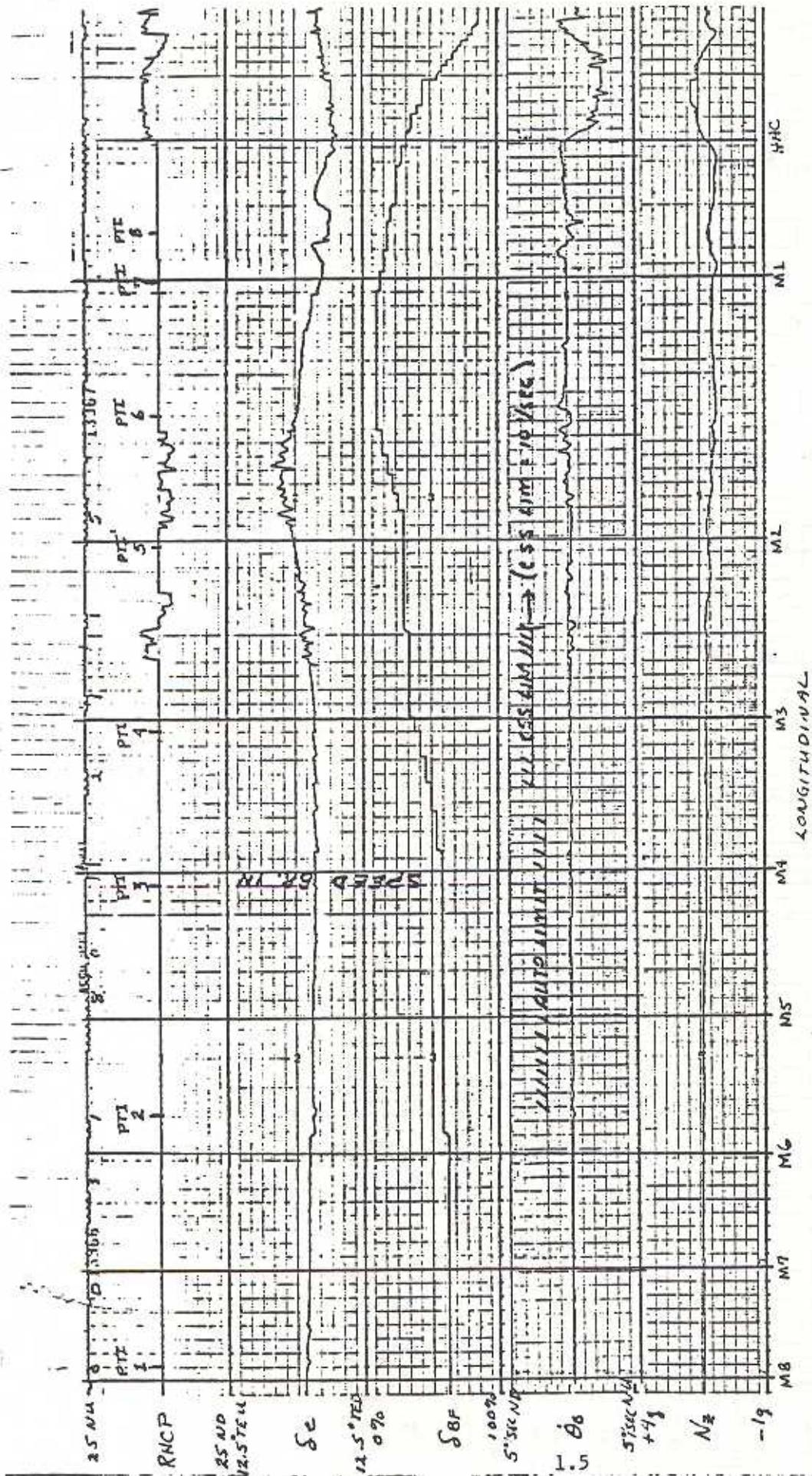


fig. 2

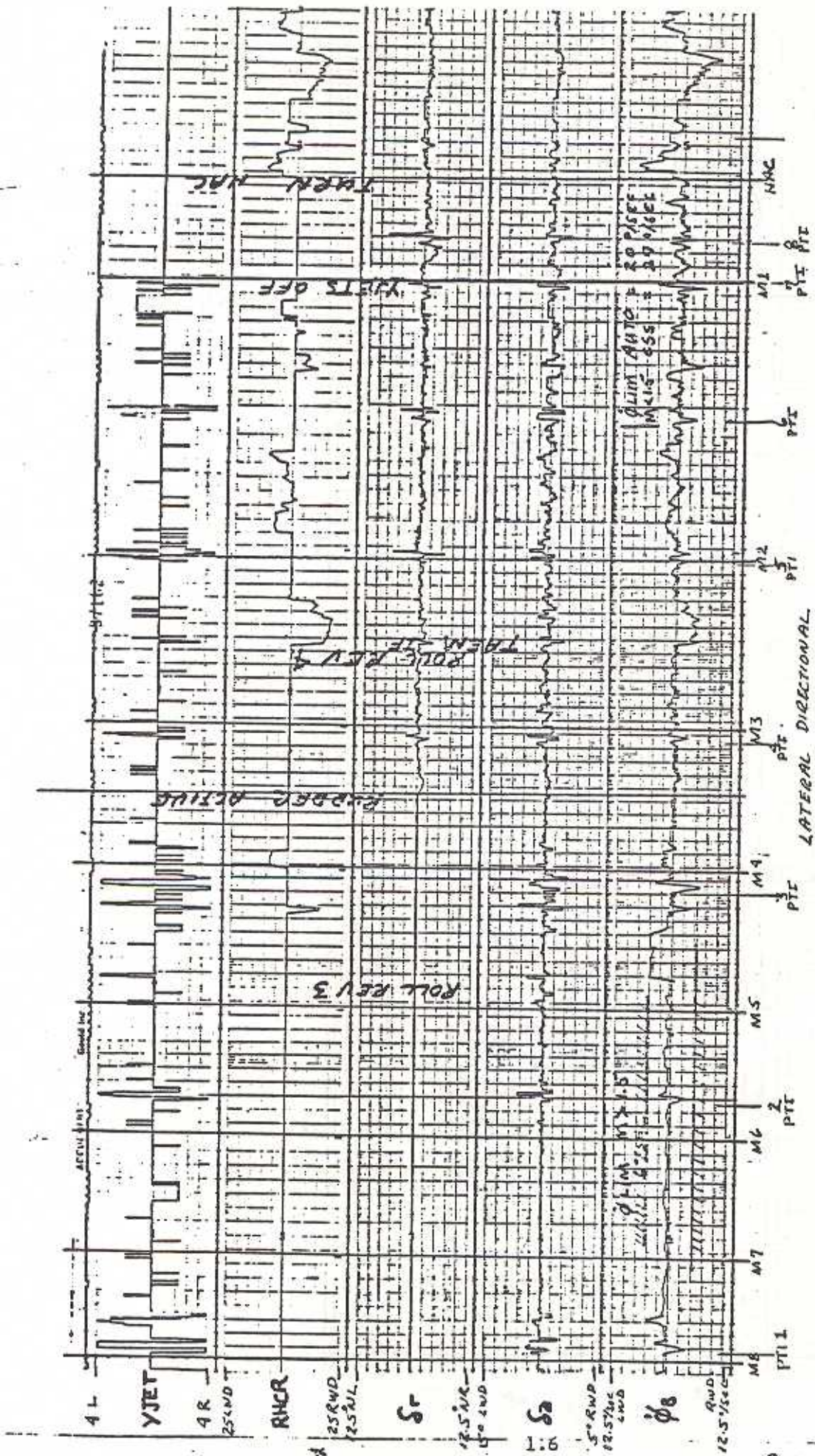


Fig.

STS-2 TRIM BODY FLAP
 PREDICTED VS FLIGHT

ENGINEERING ANALYSIS DIVISION

UNDERWOOD / ROMERE - EX33 11/21/81

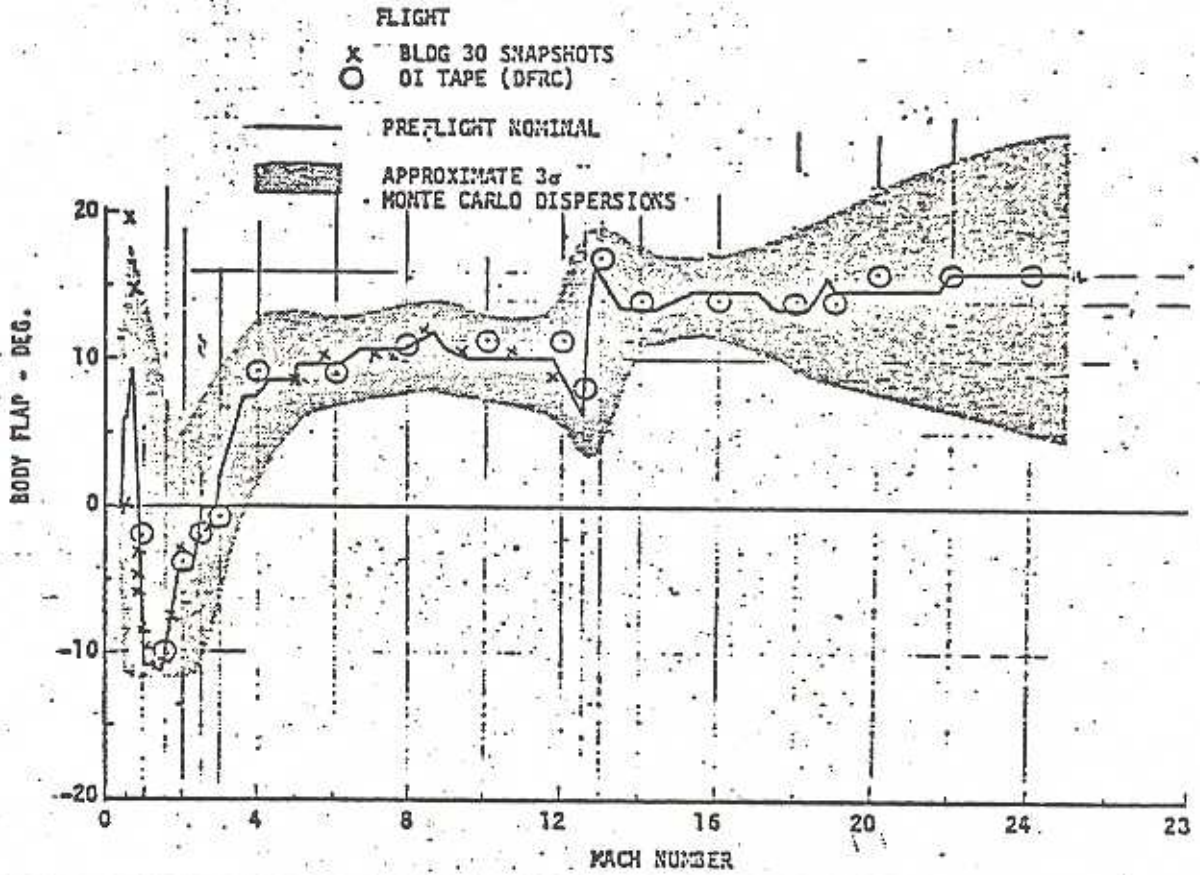


fig 4

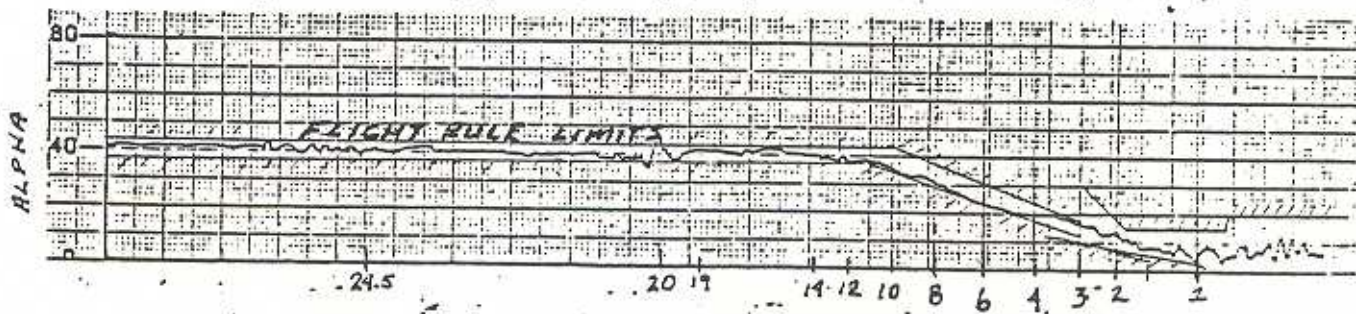


fig 5

1.7

4.1.8

Ascent DAP

A. Performance

The performance of the ascent DAP was entirely normal. SSME and SRB thrust vector control performed correctly in response to guidance and GC steer commands. Elevon load relief was nominal. The STS-2 flight experienced the same lofting that occurred on the STS-1 flight; however, the cause of this phenomenon has not yet been identified by the technical community. The one area that we believe might be causing this is in the computation of the parameter NZ_FBK which is the measured vehicle normal acceleration minus a pre-programmed reference normal acceleration.

1. Anomalies

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

2. Comparison of STS-1 & STS-2 Data

On STS-1 we did not have NZ_FBK on the downlist. Nor did we have the roll, pitch and yaw rate commands from the DAP that are sent to the MPS Command SQP for mixing. These parameters were added to our variable downlist for STS-2 and a delog of our Control Orbit display was obtained that covers the first stage time period. This was given to Gene McSwain of E&D for analysis of the lofting problem.

B. Lessons Learned - None

C. Recommendation 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 - Nonexistent after end of mission.

ORBIT DAP

A. Performance

A detailed discussion of the Orbit DAP performance is impossible without Super Thrift. This has been ordered (3 hrs) and is expected within a couple of weeks. The Super Thrift ordered covers specific tests performed on-orbit. They are:

1. TAIL Only Control
2. NOSE Only Control
3. RMS OPS (sample time period)
4. PRCS/RMS Test
5. Jet Test
6. VRCS Plume Study
7. PRCS Narrow Deadband Test

When the data arrives, these seven tests will be analyzed from the standpoint of vehicle rates and accelerations, vehicle controllability, and the effects of the RMS on vehicle rates.

All tests, with the exception of the VRCS Plume Test and the PRCS Narrow Deadband Test, were seen Real Time by the various flight controllers and appeared to proceed as expected. No surprises are expected on these tests when the Super Thrift arrives.

The VRCS Plume Test and the PRCS Narrow Deadband Test were reported to have gone well by the crew. Engle reported that the Narrow Deadband Test sounded like a "small war," so it is reasonable to assume the DAP tried to control to a $\pm .1^\circ$ limit. The Super Thrift will confirm or refute this.

In addition to my analysis E & D will use ACIP data to analyze these tests. There is some concern that the OEX failed and some data was lost, but hopefully most data will be retrievable.

1. Analysis of Each Problem

The only possible area where there might have been a problem was a configuration error at an MET of 001/22:02:40. The crew switched to DAP B/A/V ($.1^\circ$ Deadband) for a maneuver. When they should have remained in DAP A (1° Dbd). From what can be seen on Regular Thrift, they may have remained this way for 1hr. (see pg 4 of Timeline)

There were also times when the crew would switch from DAP A to DAP B before vehicle rate and attitude error was within the DAP A phase plane. This caused slightly excessive jet firings since another maneuver had to be set up by the DAP to target for the smaller deadband. Recommendations on how to avoid this problem will be discussed in Lessons Learned.

2. Comparison of STS-1 and STS-2 Data.

The only directly comparable data between STS-1 and STS-2 would be maneuver rates, vehicle attitude hold capability, and vehicle accelerations due to RCS Activity. The data available at the present time (Regular Thrift) is sufficient to confirm that there is no change between STS-1 and STS-2 on the first point. Attitude hold and vehicle accelerations requires more data. These two parameters will be examined with the Super Thrift data ordered for the Jet Test. The new Universal Pointing SPEC functions performed as required and advertised.

B. Lessons Learned

1. On at least two occasions the crew switched to the DAP with the smaller deadband before the vehicle error state had been "captured" by the larger phase plane, (i.e. switched DAP's too soon after a maneuver). To avoid this the crew should watch attitude errors on UNIV PIG and make sure (to his/her satisfaction) the vehicle attitude maneuver has completely stopped then switch DAP's.
2. It was observed during the NOSE/TAIL tests that several auto maneuvers were initiated. This occurred because the crew switched back and forth between 10° and $.5^{\circ}$ Deadbands (per checklist procedures). Whenever total error was twice the smaller deadband, the DAP would initiate a maneuver to the new phase plane target when the corresponding DAPLOAD (DAP B) was selected. This is not a system anomaly but the maneuver would be at the DAP B rate of $.5^{\circ}/s$! This is excessive and caused overshooting of the new $.5^{\circ}$ deadband. The time required to achieve vehicle control as well as the propellant required increase in this situation. It is therefore recommended that procedures be developed with this system characteristic in mind and that it be lowered in this case to $.2^{\circ}/s$. This should be the responsibility of the Orbit DAP systems engineer in the pre-flight planning (i.e. monitoring CAP, PDP, etc) and of the DAP console position for any real time changes that may occur. The maneuver rate (DISC RATE) is a parameter that will probably require constant monitoring in the future.
3. It was recommended (via 482 pre STS-2) that the maneuver rate VRCS in DAP B be changed from $.2^{\circ}/s$ to $.016^{\circ}/s$ to minimize prop usage when switching from a larger DAP A deadband to a smaller DAP B deadband. The 482 was disapproved due to the size of change (every page of the CAP). A 482 was approved, however, which changed the DAP B maneuver rate to $.016^{\circ}/s$ for the VRCS Minimum Deadband FTO (which was not performed on STS-2 due to the Minimum Mission requirements). It is therefore recommended that the DAP with the $.1^{\circ}$ attitude deadband be matched with a $.016^{\circ}/s$ maneuver rate.

C. Recommendations for Subsequent Activities

1. LCC Limit Changes - N/A. Orbit DAP software is not dependent on LC Limits

2. Flight Rules Changes - None
3. SMS Parameter/Model Changes. - None. The SMS is a correct Orbit DAP model.
4. Console or MCC Procedure Changes. - It is recommended that a detailed DAP timeline be kept real time (as Thrift allows). It is easier to remember what occurred a few hours previously than it is to remember something that happened a few days previously. Many questions have come my way (STS-1 & 2) requiring information on DAP configuration vs time.
5. Data Retrieval Accuracy - Data retrieval was worse than STS-1. Thrift deliveries lagged events by 9-11 hrs. Also, and this is especially difficult when reconstructing a detailed DAP timeline, there were numerous data gaps (even of AOS data) and overlapping times. It was, therefore, necessary to examine several Regular Thrift deliveries to be sure of a single DAP configuration! Because of the large and frequent data gaps there could have been problems which occurred totally unseen by MCC. More often than not, data was not contiguous minute to minute.

TIME (GHT)	TIME (HET)	DAP LOAD/MOD/FETS	DAP	SPAREXDS ATT/RATE	SUBMODES		PULSE LOADS		NOSE TAIL	ACTIVITY	ATTITUDE R, P, Y
					ROT	TRANS	ROT	TRANS			
316:16:08:25	000:00:58:25	A/A/N	10%/2%	DISC RATE	PLS	.1%	.1F/S	NOM	XITON TO OPS 3	L-181, 344, 360 (Z) R-181, 344, 360 (X) L-180, 0, 0 (L) R-180, 0, 0 (L) L-174, 163, 11 (L) R-174, 163, 11 (L)	
:16:49:02	101:39:02	A/A/V	1/02	DR	PLS	.01	.1	NOM		75, 90, 1308 (Z) 238, 266, 16 (L) 310, 195, 24	
:17:25:02	02:15:02	A/A/N	10/2	DR	PLS	.1	.1	NOM		310, 195, 24 (Z) 104, 92, 3 (L) 237, 101, 354 (R) 26, 147, 29 (Z) 126, 303, 331 (R) 180, 0, 0 (L) 268, 195, 25 (Z)	
:18:24:51	03:14:51	A/A/V	1/02	DR	PLS	.01	.1	NOM		61, 284, 3 (L) 309, 195, 24 (Z)	
:22:46:56	07:36:56	B/A/V	1/02	DR	PLS	.002	.02	NOM		103, 179, 4 (L) 289, 245, 13 (Z) 110, 149, 25 (L) 180, 0, 0 (L)	
:23:38:00	08:28:00	TRANS			D.A.O (OMS 3A, 3B, 4)					180, 0, 0 (L) 180, 0, 0 (L)	
317:00:07:10	08:57:10	A/A/V	1/02	DR	PLS	.01	.1	NOM			
:00:21:01	09:11:11	B/A/V	1/02	DR	PLS	.002	.1	NOM			
:02:26:04	16:104	A/A/V	1/02	DR	PLS	.01	.1	NOM			
:03:29:29	12:19:29	B/A/V	1/02	DR	PLS	.002	.01	NOM	IMU MNVR		
:03:32:29	12:22:29	A/A/V	1/02	DR	PLS	.01	.1	NOM			
:04:00:23	12:50:23	B/A/V	1/02	DR	PLS	.002	.01	NOM			
:12:34:49	21:24:49	B/H/V	1/02	PLS	PLS	.002	.01	NOM	Intenconnect	180, 0, 0 (L) 180, 0, 0 (L)	
:12:37:48	21:27:48	A/A/V	1/02	PLS	PLS	.01	.1	NOM	IMU MNVR	355, 43, 329 185, 15, 356 180, 0, 0 (L)	
:13:28:42	22:18:42	B/A/V	1/02	PLS	PLS	.002	.01	NOM		180, 0, 0 (L) 180, 0, 0 (L)	
:14:53:07	23:43:07	B/H/V	1/02	PLS	PLS	.002	.01	NOM		180, 0, 0 (L) 180, 0, 0 (L)	
:14:56:06	23:46:06	B/A/V	1/02	PLS	PLS	.002	.01	NOM		180, 0, 0 (L)	

3.4
5.1.13

17
 180, 0, 0 (L)
 180, 0, 0 (L)
 180, 0, 0 (L)
 180, 0, 0 (L)

TIME (GMT)	TIME (HET)	DAP LOAD/MODE/FACETS	DEPARTS ATT/RATE	SUBMODES		PULSE LOADS		NOSE TAIL	ACTIVITY	ATTITUDE
				ROT	TRANS	ROT	TRANS			
317:18:30:00	001:03:20:00	A/M/N	10/2	PLS	PLS	1	.5	NOM	Begin PRC/RHS TEST	180,0,0 (L) 180,0,0 (L) ~180,22,0 (L) ~180,23,0 (L) ~180,26,0 (L) ~180,27,0 (L) ~180,30,0 (L)
:18:39:19	:03:29:19	A/A/V	15/02	PLS	PLS	.01	.5	NOM		
:18:40:55	:03:30:55	A/M/N	10/8	PLS	PLS	1	.5	NOM		
:18:41:55	:03:31:55	A/A/V	15/02	PLS	PLS	.01	.5	NOM		
:19:02:52	:03:52:52	A/A/V	11/02	DR	PLS	.01	.5	NOM	MNVR	149,90,10 (L) 149,90,10 (L)
:19:13:50	:04:03:50	B/A/V	11/02	DR	PLS	.002	.02	NOM	End of PRC/RHS TEST	177,8,3 (L) 177,7,3 (L)
:19:42:16	:04:32:16	B/A/N	5/2	DR	PLS	.04	.02	NOM	Begin VRCS HTR TEST FTO-212-03	180,0,0 (L) 180,0,0 (L)
:19:53:22	:04:43:22	A/A/N	5/2	DR	PLS	.1	.1	NOM		180,0,0 (L) 180,0,0 (L)
:20:05:04	:04:55:04	A/A/N	5/2	DR	PLS	.1	.1	TAIL	Begin of TAIL Only Tail	180,4,3 (L) 180,4,3 (L)
:21:13:38	:06:03:38	B/A/N	5/2	DR	PLS	.04	.02	NOM	SIR-A	180,0,0 (L)
:21:42:26	:06:32:26	A/A/N	5/2	DR	PLS	.1	.1	TAIL	FTO	182,0,355 (L) 182,0,355 (L)
:22:24:00	:07:14:00	B/A/N	5/2	DR	PLS	.04	.02	NOM	SIR-A	180,0,0 (L)
:22:26:36	:07:16:36	A/A/N	5/2	DR	PLS	.1	.1	TAIL	FTO	178,0,1 (L) 178,0,1 (L)
:22:48:00	:07:38:00	B/A/N	5/2	DR	PLS	.04	.02	NOM	SIR-A	185,4,355 (L) 185,4,355 (L)
:23:14:31	:08:04:31	A/A/N	5/2	DR	PLS	.1	.1	TAIL	FTO	185,4,355 (L) 185,4,355 (L)
319:00:42:25	:09:32:25	A/A/N	10/2	DR	PLS	.1	.1	NOSE	FTO 274-01	185,358,20
:00:46:01	:09:36:01	A/A/N	10/2	DR	PLS	.1	.1	TAIL	FTO	185,357,21

3.5

4.1.14

TIME (GHT)	TIME (HET)	DAP LOAD/MOOS/SET	DEGRADATION ATT/RATE	SUBNODES		PULSE LOADS		NOSE TAIL	ACTIVITY	ATTITUDE R, P, Y
				ROT	TRANS	ROTATION	TRANSLATION			
:01:04:37	:01:09:40:00	A/A/N	10/2	DR	PLS	.1	.1	NOSE	FTO 274-01	185, 352, 3 (L)
:01:10:00	:01:15:41:37	B/A/N	15/2	DR	PLS	.04	.02	NOM	SIR-A	185, 352, 3 (L) 180, 10, 0 (L)
:02:17:00	:10:00:00	A/A/N	10/2	DR	PLS	.1	.1	NOSE	FTO 274-01	180, 0, 0 (L)
:02:21:01	:11:11:01	B/A/N	15/2	DR	PLS	.1	.1	TAIL	FTO	178, 355, 6 (L) 178, 355, 6 (L) 177, 0, 2 (L)
:02:22:01	:11:12:01	A/A/N	10/2	DR	PLS	.1	.1	TAIL	SIR-A	177, 0, 2 (L) 181, 2, 0 (L)
:02:23:01	:11:13:01	A/M/N	15/2	DR	PLS	.3	.1	TAIL	FTO	181, 2, 0 (L)
:02:25:01	:11:15:01	A/M/N	10/2	PLS	PLS	.3	.1	TAIL	FTO	184, 5, 359 (L) 184, 5, 359 (L)
:02:30:23	:11:20:23	B/M/N	5/2	PLS	PLS	.04	.02	P-NOM Y-TAIL	FTO 247-01	189, 12, 353 (L) 187, 12, 359 (L)
:02:44:23	:11:34:23	A/M/N	10/2	DR	PLS	.3	.1	TAIL	FTO	202, 53, 355 202, 53, 355 (L)
:02:50:23	:11:40:23	A/A/N	15/2	DR	PLS	.04	.02	NOM	End of Jet Test FTO 247-01	229, 221, 339 (L) 226, 253, 340 (L)
:02:52:39	:11:42:39	B/A/N	15/2	DR	PLS	.04	.02	NOM	End of VRES FTO 212-03	226, 253, 340 (L) 219, 268, 342 (L)
"	"	"	"	"	"	"	"	"	PRCS Normal DB FTO 274-07	205, 310, 354 (L) 205, 310, 354 (L)
:02:54:37	:11:44:39	A/A/V	11/02	DR	PLS	.01	.1	NOM	VRES Plume	200, 320, 0 (L)
:02:55:39	:11:45:39	A/M/V	11/02	Accel	PLS	.01	.1	NOM	FTO 274-11	200, 320, 0 (L)
:03:09:36	:11:57:36	A/A/V	11/02	DR	PLS	.01	.1	NOM	*THU MNUVR	205, 125, 353 (L) 216, 227, 8 (L)
:04:29:01	:13:14:01	B/A/V	11/02	DR	PLS	.002	.02	NOM	SLEEP	180, 0, 0 (L) 180, 0, 0 (L)

* THU MNUVR began @ 318:02:56:00

3.6
4.1.15

TIME (GMT)	TIME (MET)	DAP LOAD/MODE/SETS	DIARRANDS ATT/RATE	SURMODES		PULSE LOADS		NOSE TAIL	ACTIVITY	ATTITUDE
				ROT	TRANS	ROTSW	TRANS			
318:12:51:24	00:21:41:24	A/A/V	1/.02	DR	PLS	.01	.1	NOM	* IMU MNVR	167, 0, 358 (L) 167, 358, 353 (L)
:13:22:40	:22:13:46	B/A/V	.1/.02	DR	PLS	.002	.02	NOM	Config switched to 8/11 for common out of config	180, 0, 0 (L) 180, 0, 0 (L)
:14:23:00	:23:13:00	A/A/V	u	DR	PLS	0	0	D	In OPS 8 For FCS	180, 0, 0 (L) 180, 0, 0 (L)
:14:56:02	:23:46:02	A/A/V	0	DR	PLS	0	0	0		197, 227, 303 (L) 197, 227, 303 (L)
:15:04:42	:23:54:42	A/M/V	0	PLS	PLS	0	0	0	CP	181, 241, 309 (L) 181, 249, 309 (L)
:15:20:13	00:00:10:13	A/A/V	0	PLS	PLS	0	0	0	FCS	158, 305, 340 (L) 158, 305, 340 (L)
:15:28:46	:01:00:46	A/M/V	0	PLS	PLS	0	0	0		195, 358, 305 (L) 195, 358, 305 (L)
:15:37:00	:00:27:00	A/M/V	0	PLS	PLS	0	0	0		214, 37, 307 (L) 214, 37, 307 (L)
:15:45:00	:00:35:00	A/A/V	1/.02	DR	PLS	.01	.1	NOM	Back in OPS 2 (IMVR)	180, 66, 323 (L) 180, 66, 323 (L)
:17:16:15	:02:06:15	A/A/V	1/.02	PLS	PLS	.002	.02	NOM		
:18:30:36	:03:20:36	B/A/V	.1/.02	PLS	PLS	.002	.02	NOM		
:18:56:00	:03:46:00	A/A/V	1/.02	PLS	PLS	.01	.1	NOM		
:19:10:40	:04:00:40	TRANSITION TO OPS 3								

* IMU MNVR began @ 318:12:50:24
 ** Out of Config mnvr began @ 318:13:10:00

3.7

4.1.16

TRANS DAP

A. Performance

The TRANS DAP for STS-2 featured the addition of the RCS AUTO maneuver capability. There were four AUTO maneuvers performed during the mission, and from a control standpoint presented no problems. The maneuvers were completed in nominal times with the attitude and rate data indicating there were no control problems.

The first AUTO maneuver was performed between the OMS 1 and OMS 2 burns. The ground computed and actual maneuver time was equal, at 590 seconds, for the AUTO maneuver rate of 0.2° per second, and a total eigen error of 118°. The remaining maneuvers were also nominal.

1. Problem Analysis

Close attention should be paid to crew procedures to prevent unexpected maneuvers when going to the TRANS DAP since it is initialized in the AUTO mode. Data is still not available to evaluate the initial transition from OPS 2 to OPS 3, but the second time it was done the crew immediately selected manual control and prevented an undesired maneuver. A software change to eliminate this problem has not been developed.

2. The STS-1 and STS-2 data compared in an identical fashion.

B. Lessons Learned

Too much cannot be logged in real time concerning DAP configurations. The control console should keep a running account of DAP modes.

C. Recommendations

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 - the thrift system needs a massive rework. There are cases when attempting to analyze a single event requires working with 40-50 pages of microfiche.

AUTOLAND

A. Performance

Prior to entering the heading alignment phase, the vehicle was established on a nominal energy trajectory and was following nominal groundtrack. The vehicle was trimmed and established in a steady state attitude in the longitudinal axis with only some minor perturbations in pitch attitude (θ). In the lateral/directional axes, the vehicle was less stabilized due to high winds but was wings level for approximately 8 seconds prior to intercepting the HAC. Speedbrake modulation was active and appears to be functioning correctly based \bar{q} and KEAS stripcharts. Increasing \bar{q} above \bar{q}_{ref} (due to high tailwinds) caused the speedbrake to be commanded to 100% which it attained 2 seconds after the initial roll command into the HAC.

Commander (CDR) took manual control in pitch/roll/yaw to initiate the HAC maneuver at 318:21:19:11 GMT (subsequent time references will give only minutes and seconds). The vehicle rolled to $\theta = -60^\circ$ in approximately 8 seconds ($\max \dot{\theta}_{body} = 10$ o/s) going just outside of the HAC and experienced normal acceleration (N_{body}) of 1.6 g increasing to 1.9 g as CDR increased the roll to bring the vehicle inside of the HAC. Then, CDR rolled the vehicle passed wings level to $\theta = 5^\circ$ for approximately 10 seconds (:19:56-20:06) causing the vehicle to cross outside of the HAC. Speedbrake remained at 100% as \bar{q} continued to increase during this portion of the HAC while the body flap was approaching saturation at 98%.

As CDR commanded $\theta = -25^\circ$ into 60 kt. headwinds to maintain proper groundtrack around the HAC, the vehicle began to get into a low energy situation with speedbrake at 100% while \bar{q} began to decrease rapidly from 290 psf -250 psf. Guidance commanded the speedbrake to close at the same time as CDR engaged auto P/R/Y (:20:14) which immediately commanded $\theta_c = -50^\circ$ with maximum $\dot{\theta} = 6$ o/s; body flap saturated at 98%. Approximately 2 seconds later (:20:16), CDR engaged left SBTC and commanded 10% to begin speedbrake sweep; body flap ramped to trail in 6 seconds to support the elevons during the change in pitch attitude ($+\dot{\theta}$). Pitch guidance commanded $N_{zc} = +.5g$ commensurate with speedbrake closing which caused \bar{q} to decrease from 250 psf-220 psf.

CDR engaged CSS P/R/Y and manual body flap (:20:31) for the sweep. Aerosurfaces were as follows during the sweep:

	δ_{SB}		δ_E
Open: 10%-100%, 15 sec;	$\dot{\delta}_{SB} = 5.2$ o/s		+ 3.0 ^o - + 8.5 ^o
Close: 100%-10%, 9 sec;	$\dot{\delta}_{SB} = 8.7$ o/s		+ 8.5 ^o - + 3.5 ^o

Longitudinal control was good throughout the sweep as was lateral/directional control as the vehicle maintained a constant $\theta = -20^\circ$ and was aligned on proper groundtrack. There was no appreciable loss of \bar{q} during the sweep.

Approximately 7 seconds after completion of the speedbrake sweep (:21:04), CDR commanded + roll to roll the vehicle out of the HAC (h = 12900') and 6 seconds later engaged auto P/R/Y for initiation of A/L (:21:10, h = 12300'). At this time, the vehicle was left of the runway centerline and below the glideslope. (MLS lock-on had occurred at :20:35 while CSS mode was selected therefore any guidance commands subsequent to that time were transparent to flight control). Immediately guidance issued roll commands to null lateral deviation from runway centerline which maneuvered the vehicle to roll angles of 19.7°, -19°, 9° before nulling at :21:42 (h = 10200'). Highest roll rate was $\dot{\theta}_{body} = 8.5$ o/s with good damping after each roll.

Simultaneously, in the pitch axis, guidance commanded $N_z \approx +.5g$ to try to capture the glideslope (altitude reference is a function of predicted range in TAEM) causing the vehicle to pitch up at $\dot{\theta}_{body} = 2.8$ o/s and pull $N_z = 1.49$ g. This maneuver caused \bar{q} to drop from 230 psf-165 psf and reduced altitude rate (\dot{h}) to 0 fps at h = 11800' during the time period :21:18-:21:24. In addition, this maneuver precipitated the following lightly damped, second order longitudinal oscillations which continued past the forced TAEM guidance termination (:22:15) at 5000' altitude:

$$\begin{aligned} N_z &: 3.5 \text{ cycles, } T = 21 \text{ sec, } |N_z| = 1 \text{ g p-p max} \\ \dot{\alpha} &: 3.5 \text{ cycles, } T = 21 \text{ sec, } |\dot{\alpha}| = 7^\circ \text{ p-p max} \\ \dot{\theta} &: 3.5 \text{ cycles, } T = 20 \text{ sec, } |\dot{\theta}| = 4.2 \text{ o/s p-p max} \end{aligned}$$

Dynamic pressure decreased to a constant $\bar{q} = 160$ psf during the oscillations. This low \bar{q} caused the magnitude of the N_{zc} (the forcing function of the oscillations) to decrease during the oscillations due to \bar{q} limiting of the unlimited N_{zc} . (Speedbrake was closed therefore there was no additional energy reserve. If δ_{sb} were greater than zero, guidance could have commanded $\delta_{sbc} = 0$ thus increasing energy and allowing the magnitude of $+N_{zc}$ to increase). As a result, the vehicle's altitude versus range was increased to a point near to but still insufficient to capture the glideslope by the final transition requirement. An informational note, A/L transition requirements are as follows:

$$\begin{aligned} (1) \text{ } h > 10000': & \quad |h_{err}| < 1000' \text{ and} \\ & \quad |y| < 1000' \text{ and} \\ & \quad |\alpha_{err}| < 4^\circ \text{ and} \\ & \quad |\bar{q}_{err}| < 1 \text{ psf} \end{aligned}$$

$$\begin{aligned}
 (2) \quad 10000' > h > 5000': \quad & | h_{err} | < (.19h - 90') \text{ and} \\
 & | Y | < (.18h - 80') \text{ and} \\
 & | \gamma_{err}^1 | < (.0007h - 3^\circ) \text{ and} \\
 & | \bar{q}_{err} | < 24 \text{ psf}
 \end{aligned}$$

(3) $h = 5000'$: force

Note also that the guidance community believes that even had the transition requirements for h_{err} , Y and γ_{err}^1 been satisfied, the \bar{q}_{err} requirement would not have been met and a forced TAEM guidance termination would still have resulted.

Upon transition to approach/landing phase (:22:15) guidance still trying to capture the glideslope commanded a $+\Delta N_z$ then $-\Delta N_z$ while the vehicle was in the final 1/2 cycle of the longitudinal oscillation (N_z and δ_e were decreasing during the time period :22:12-:22:21). The vehicle initially pitched up at $\dot{\theta} \approx .5$ o/s then pitched down at $\dot{\theta} \approx -1.5$ o/s (during :22:16-:22:21) and captured the glideslope at :22:21 ($h \approx 4600'$). Guidance transitioned to steep glideslope (SGS) subfunction where the vehicle established longitudinal trim resulting in increased \bar{q} from 160 psf-260 psf and increased KEAS from 220 KEAS-280 KEAS. During SGS, elevator oscillations of $T = 1.25$ sec and amplitude $|\delta_e| = .5$ o/s-1.0 o/s p-p are evident (actual frequency may be higher but unrecorded due to recorder speed). Low amplitude θ oscillations about $\theta = 0$ o/s can be seen corresponding to δ_e while N_z and α appear constant and transparent to the high frequency oscillations. At :22:39 ($h \approx 2000'$) guidance transitioned to flare and shallow glideslope (FSGS) subfunction and initiated pullup. The vehicle pitched up to a constant $\dot{\theta} = 1$ o/s and N_z increased to a constant $N_z \approx 1.1$ g consistent with the constant g circle commanded by guidance during circularization subfunction of FSGS. Elevator oscillations are evident again in FSGS but are of reduced amplitude ($|\delta_e| \approx .5^\circ$ p-p) and slightly higher frequency ($T \leq 1$ sec.). There are small but apparent oscillations in θ (about $\dot{\theta} = 1$ o/s) and N_z (about $N_z = 1.1$ g) but the vehicle was stabilized and trimmed longitudinally with no oscillations in α .

At :22:41 ($h \approx 1900'$) CDR engaged CSS R/Y and at :22:49 ($h \approx 800'$) PRHC was moved sufficiently out of detent to engage CSS pitch. (CDR claims pitch CSS PBI was engaged simultaneously with CSS R/Y PBI but this is still uncorroborated due to slow data return.)

1. Anomalies

The only unexplained performance is the elevator oscillations in SGS and FSGS. Two possible explanations are: 1) guidance and control interaction (although $T_{A/LGuid} = .16$ sec which is $w = 39.3$ rad/sec and too high a frequency for flight control) or navigation and control interaction ($T_{A/LNav} = 2.0$ sec which is $w = 3.14$ rad/sec and well within flight control bandwidth) or 2) wind gusts and turbulence. Further study should be done on this problem.

B. Lessons Learned

- o Speedbrake commands in TAEM guidance must take into consideration that strong tailwinds entering the HAC will be strong headwinds rolling out of the HAC and possibly result in a low energy situation.
- o \bar{q} limit on N_{zc} in TAEM can prevent the vehicle from capturing the glideslope, product phugoid oscillation and force A/L transition in a low energy situation. Perhaps A/L transition should be forced at $h > 5000'$.

RECOMMENDATIONS

1. No LCC limit change.
2. The following limit/constraint as defined in OFT Flight Rule 8-30E was violated and should be considered for revision:

- o $N_z \text{ max} < 1.9 \text{ g}$

There was data dropout during peak g's in the HAC but the vehicle appears to have suffered no deformation or damage.

Concerning limit/constraint:

- o Autoland
 - o If no 'A/L' by 6000' - CSS

This rule was violated but A/L did a good job of establishing the vehicle on the glideslope. However, it is not certain that the vehicle would have reached the runway in A/L given the strong headwinds and low energy situation. The vehicle can be allowed to descent below 6000' altitude in Auto TAEM and force A/L transition to capture the glideslope but not allowed to touchdown or rollout in A/L to prevent landing short of the runway (if no 'A/L' by 6000').

3. SMS - no change.
4. Console - no change.
5. Data retrieval - need a better system.

ENTRY TEST MANEUVERS

A. Performance

The planned entry test maneuvers: 8 ASI's, 9 PTI's, 3 body flap pulses, 1 POPU, and 1 speedbrake sweep, were all performed satisfactorily. The structural PTI-0 was terminated prior to its completion providing 4 seconds of the desired 16 seconds of data. Based on OI data all STS-2 ASI's, PTI's, and bank reversal motions were very close to that predicted by preflight simulations. STS-2 and SMS PTI comparisons are shown in enclosure 1.

The STS-2 vehicle longitudinal trim as indicated by the bodyflap position was very close to that observed on STS-1. Comparison of STS-2 and STS-1 elevon and bodyflap positions is shown in enclosure 2. This suggests that the STS-2 and STS-1 Xcg's were nearly the same and not as different as predicted premission. Post STS-2 vehicle weight and balance results show the Xcg to be 3.2 in. further aft than predicted which supports the bodyflap trim observations.

ACIP, high sample rate (174 samples/second) data was not recorded due to a broken drive belt. The same type of data is provided by OI but with less resolution, accuracy, and time skew difficulties. Consequently, the confidence level of the MLE aerodynamic coefficient predictions will be decreased.

B. Lessons Learned

Essential aerodynamic, structural, and thermal data has been lost on both STS-1 and STS-2 flights due to recorder malfunction. Repeated loss of this data would expectedly impact the timely removal of flight placards.

C. Recommendations

1. LCC limit changes - None
2. Flight rule changes - Review existing flight rules with the intent of relaxing them with experience and data analysis.
3. SMS Parameter/Model changes - None
4. Console or Procedure changes - None
5. Data Retrieval adequacy - Provide for onboard simultaneous recording of ACIP data.



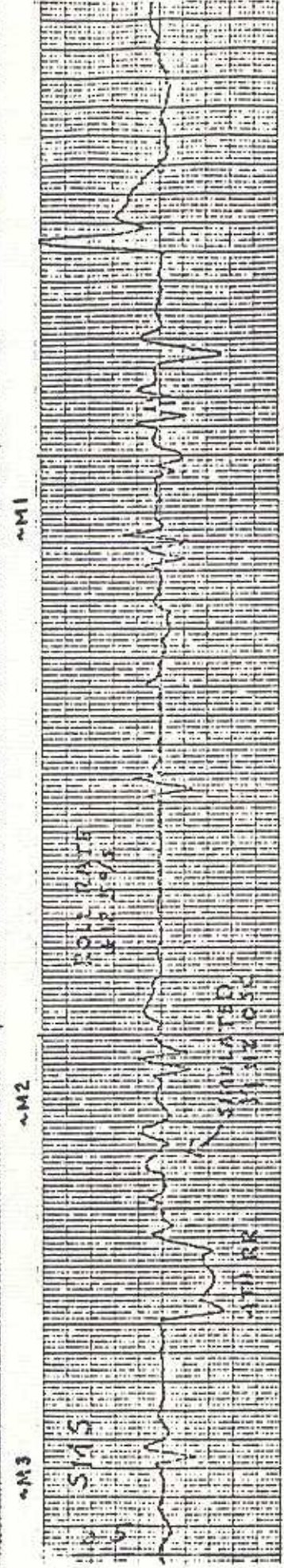
4.1.23



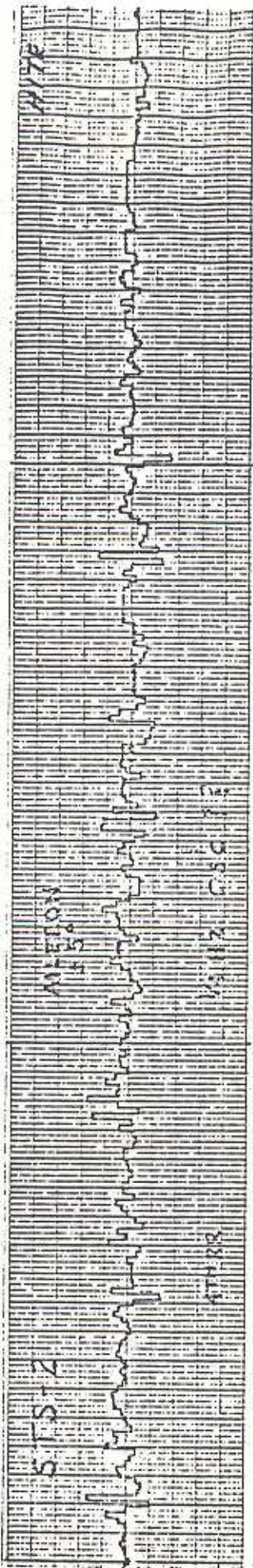
4.1.24



4.1.25



4.1.26

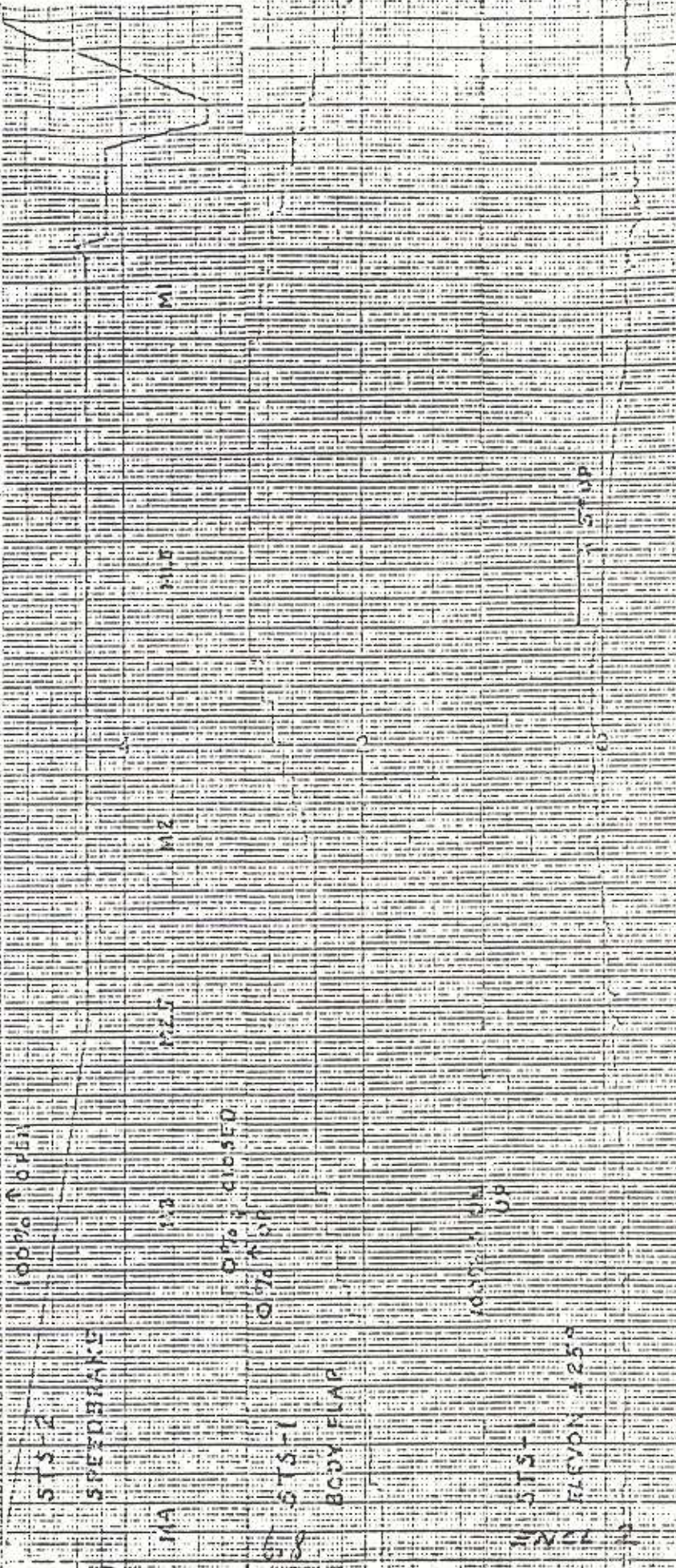


4.1.27



4.1.28

HITE



4.1.29

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 1, and in the SODB, volume 1, table 3.4.5.1-2. The AA power was left on in OPS 2 to protect the tungster filament in the incandescent lamp.

STS-2 OPS 8 AA SELF TEST DATA								
AA	Y		Y		Z		Z	
	DATA	LIMITS	BIAS	LIMITS	DATA	LIMITS	BIAS	LIMITS
1	16.589	16.1±1.7	-0.064	0.00±0.45	65.379	64.4±6.7	-0.257	0.00±1.29
2	16.654	16.1±1.7	+0.064	0.00±0.45	66.409	64.4±6.7	+0.257	0.00±1.29
3	16.525	16.1±1.7	+0.064	0.00±0.45	64.865	64.4±6.7	-0.257	0.00±1.29
4	15.882	16.1±1.7	+0.064	0.00±0.45	66.152	64.4±6.7	-0.257	0.00±1.29

1. The MCC has incorrect cal curves for OPS 8 accelerometer data downlinked in FPS 2. MCC will be changed to have separate cal curves for OPS 8 and OPS 1, 3. System software was implemented with data in G's for OPS 1 and 3, and FPS 2 for OPS 8.
 2. AA performance for both STS-1 and 2 was nominal, and the data reviewed compared favorably.
- B. System performance was nominal, requiring no change in system operations.

C. Recommendations

1. No LCC limit change requirements are recommended.
2. Flight rule changes are not recommended.
3. No SMS changes recommended.
4. Console procedure was implemented for STS-1 and STS-2 to transition from ASCENT to ORBIT MCC OPERATIONAL LIMIT sense at MECO. This was done to support monitoring of OMS engine positions. This requires a MED input during prelaunch and MED input after transition to OPS 2 for accelerometer operational limit sense.
5. In general, data retrieval was adequate. Due to incorrect OPS 8 MCC cal curve, accelerometer data (thrift and MCC display data) required division by 32.174 prior to data evaluation.

AERO ACTUATORS

A. Performance

All aero actuators performed normally for all phases. Performance compared very close with STS-1 with the exception of expected excited driver currents during PTI and quieter driver currents just prior to landing which was a result of the pitch channel being in auto.

There was concern by some experts that the cold temp of the hydraulic fluid ($\sim 50^{\circ}\text{F}$) would cause some problems during OPS 8 FCS checkout, i.e., wrong channels bypass, drive rates low, etc., while all the data has not been analyzed in great detail, it appears that the actuators performed within specification.

1. Analysis of problems

During the FCS checkout the negative stimuli channel bypass test for the speedbrake did not work properly. For this test all four channels are commanded to 10% (normal). Then a negative stimuli command of -14% is issued and removed to each channel sequentially. The -14% drives the command past 0% and the software wraps this around to issue a positive stimuli command. As a result we get two positives stimuli test during FCS C/O. We were aware of this problem, and had previously observed it in simulations.

A "Body Flap Fail" message occurred at OPS 1 transition on first launch attempt on November 5, 1981. This is a problem we will probably see again and is caused by the body flap not being positioned near trail ($< 40\%$) at the end of aero surface drive test several weeks prior to launch. At the completion of this test, if the B/F is between 34.2% and 50%, the aerosurface initiate (AI) routine in OPS 9 will not reposition the B/F. If the B/F is outside these limits the AI routine will position the B/F to 41.6%. Even this value will cause a "Body Flap Fail" message at OPS 1 transition.

This message did not reoccur on November 11, because the B/F had been positioned to trail (34.2%) during the first launch attempt on November 5.

2. Comparison of data

STS-2 actuator signatures were very close to STS-1. Secondary delta pressures offsets were of the same magnitude and direction. Driver current activity and amplitudes were close to STS-1 except for increased activity during PTI's and reduced activity while in auto pitch during landings.

B. Lesson Learned

We have a terrible data retrieval system. Playbacks are slow and its difficult to determine who has priority for playbacks. Thrift is ok for post flight analysis but it is hard to use when you are also trying to work realtime problems.

C. Recommendations for Subsequent Activity

1. LCC limit changes

No comments

2. Flight rule changes

No comments

3. SMS parameter/model changes

The SMS output the secondary delta pressure with a reverse sign to the actual vehicle. This requires the ground to use two que cards (one for SMS and one for flight) to isolate a one on one channel force fight. If the wrong channel is isolated, the surface will drive to the stops. This needs to be fixed.

4. Console or MCC procedure changes

The Control Console is badly in need of a display request keyboard (DRK). During FCS C/O, if we are to monitor it, we have to cycle through 20 displays to verify SW contacts and actuator performance. Contacts are momentary and cannot be captured on history tabs unless observed.

The eight SCR's that are operated by Control should have remote start on Control Console.

The event SCR's are not much use--they are old, they frequently do not run (paper does not feed through). Perhaps we should give up the requirement for the event SCR's.

5. Data retrieval

We need a good data retrieval system and MDR's, like we had on Skylab would do fine. What ever it is, it needs to be under the control of the console operator who needs the data.

AIR DATA SYSTEM (ADTA)

A. Performance

The ADTA performance during major mode 304, 305 was nominal. The flight data was reviewed with no discrepancies noted. When data is available, a further analysis of the Baro vs Nav derived data will be performed. The times were noted for the following system functions:

318:21:15:48	AIR DATA PROBE DEPLOY	3.12 MACH	95K HPC
318:21:15:49	ADTA DATA GOOD FLAG	3.10 MACH	95K HPC
318:21:16:44	ADTA DATA TO G&C	2.20 MACH	80K HPC

The ADTA data from the OPS 8 sensor self test satisfied the bite and limit test requirements in the PDP section 1, and in the SODB, volume 1, table 3.4.5.1-2.

2. ADTA performance for both STS-1 and STS-2 was nominal and the data reviewed compared favorably.

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

C. Recommendation:

1. No LCC limit changes recommended.
2. Flight rule changes are not recommended.
3. No SMS changes recommended.
4. The MCC "ADTA 1, 2, 3, 4 delta" event lights cycled when ADTA OPS 8 software was active and system was not in self test. MCC avionics operational limits were set too low and will be readjusted according to transducer bias and new RM thresholds for STS-3.
5. In general, data retrieval was adequate. Post mission data retrieval delayed system evaluation.

STS-2 OPS 8 ADTA SELF TEST DATA

ADTA	TRANSDUCER		BIAS	
	PS	PxC	PxU	PxL
1	0.00	-0.002	-0.002	-0.003
2	-0.03	-0.01	-0.002	-0.01
3	-0.002	0.00	-0.002	-0.003
4	0.00	-0.002	0.001	0.01

ADTA HIGH TEST	PS		PxC		PxU		PxL		T	
	DATA	LIMITS	DATA	LIMITS	DATA	LIMITS	DATA	LIMITS	DATA	LIMITS
1	0.8141	0.814 ± .001	5.4748	5.475 ± .002	2.7423	2.742 ± .002	1.7107	1.710 ± .002	173.580	173.63 ± .07
2	0.8141	0.814 ± .001	5.4748	5.475 ± .002	2.7423	2.742 ± .002	1.7107	1.710 ± .002	173.580	173.63 ± .07
3	0.8141	0.814 ± .001	5.4748	5.475 ± .002	2.7423	2.742 ± .002	1.7107	1.710 ± .002	173.580	173.63 ± .07
4	0.8141	0.814 ± .001	5.4748	5.475 ± .002	2.7423	2.742 ± .002	1.7107	1.710 ± .002	173.580	173.63 ± .07

ADTA LOW TEST	PS		PxC		PxU		PxL		T	
	DATA	LIMITS	DATA	LIMITS	DATA	LIMITS	DATA	LIMITS	DATA	LIMITS
1	24.8884	24.888 ± .001	29.576	29.529 ± .002	21.7089	21.710 ± .002	14.7138	14.715 ± .002	18.520	18.52 ± .02
2	24.8884	24.888 ± .001	29.576	29.529 ± .002	21.7089	21.710 ± .002	14.7138	14.715 ± .002	18.520	18.52 ± .02
3	24.8884	24.888 ± .001	29.576	29.529 ± .002	21.7089	21.710 ± .002	14.7138	14.715 ± .002	18.520	18.52 ± .02
4	24.8884	24.888 ± .001	29.576	29.529 ± .002	21.7089	21.710 ± .002	14.7138	14.715 ± .002	18.520	18.52 ± .02

ASCENT TVC ACTUATORS

A. Performance

This report is a review of ascent thrust vector control (TVC) actuator operation during STS-2. Specific subsystems covered include main engine pitch and yaw actuators and solid rocket booster, rock, and tilt actuators.

The SRB's functioned as expected with no noted anomalies. Table 1. below contains flight data of selected SRB parameters and times. Some of this data was recorded real time on strip chart recorders. The remainder of the data was collected from super thrift. Strip-chart recorder data provides an excellent record of the trend of SRB actuator secondary delta pressure throughout the period of operation. Super thrift data complemented the delta P's collected on SCR's but some parameters (actuator selected commands, position feedbacks, driver currents) are not available on super thrift until several days after flight.

Main engines also performed within specified tolerances, although minor vehicle oscillations were noted during the time that the main engines were being commanded to the dump position.

Background:

After MECO the ME's are driven to the dump position to expell excess fuel during the OMS 1 burn. The rate at which the actuators are driven is 1 HZ and the actuators are moved in 1° steps.

1. Analysis of Each Problem

No SRB problems were noted as was mentioned earlier. No ME failure were noted either, however, vehicle oscillations resulting from ME movement is a matter of concern. Oscillations were observed in the pitch axis during ME movement from the position at MECO to the dump position. It is believed that the oscillations are caused by the large actuator movements (1° /step).. The amplitude of vehicle oscillation during this time was 0.6° peak to peak. CR 39360A, scheduled for version 19, STS-5 implementation will change the actuator movement rate and increment from 1HZ and 1° /step to 12.5HZ and $.08^{\circ}$ /step. The time required to move the engine bells to the dump position remains unchanged, but each increment of movement is smaller. This action should reduce if not entirely eliminate the oscillations.

2. Comparison of STS-1 & STS-2 Data

SRB actuator performance showed little difference between STS-1 & STS-2. Main engine performance during ascent remained about the same with one important exception. Oscillations increased from $.5^{\circ}$ peak to peak to $.6^{\circ}$ peak to peak. The duration of these oscillations remained about the same.

B. Lessons Learned - None

C. Recommendations For Subsequent Activities

1. LCC Limit Change - None
2. Flight Rules Changes - None
3. SMS Parameter/Model Changes - None
4. Console or MCC Procedure Changes - None
5. Data Retrieval Adequacy - A quicker turn around of super thrift data will improve post flight analysis.

L SRB

	ROCK				TILT			
	ΔPA	ΔPB	ΔPC	ΔPD	ΔPA	ΔPB	ΔPC	ΔPD
APU ON	0	-40	0	+20	+20	+60	0	+15
SRB SLEW	-1095	+1034	-730	+426	-913	+608	+365	+365
SRB SEP	+183 \pm 25	-365 \pm 120	+487 \pm 40	-243	+450 \pm 100	-304 \pm 100	+304 \pm 120	-304 \pm 60

All values in PSI

R SRB

	ROCK				TILT			
	ΔPA	ΔPB	ΔPC	ΔPD	ΔPA	ΔPB	ΔPC	ΔPD
APU ON	?	0	0	-45	+40	0	0	-25
SRB SLEW	?	+726	-484	-380	-847	+847	-830	+475
SRB SEP	?	-121	+242	-242	+121	-153	+484 \pm 75	-484 \pm 60

FIGURE 1

10.3

4.1.37

CME

	PITCH				YAW			
	ΔPA	ΔPB	ΔPC	ΔPD	ΔPA	ΔPB	ΔPC	ΔPD
APU ON	60±43	+61±42	0	+117	+117	-100	-42	-23
L/O	+242±15	-10±4	+200±33	+121±19	+150±150	0±363	+250±484	-182±242

LME

	PITCH				YAW			
	ΔPA	ΔPB	ΔPC	ΔPD	ΔPA	ΔPB	ΔPC	ΔPD
APU ON	-118	0	+121	-150	+90	-121	+150	-181
L/O	+181±60	-60±60	+180±60	-242±60	+180±60	-242±121	+300±121	-304±50

RME

	PITCH				YAW			
	ΔPA	ΔPB	ΔPC	ΔPD	ΔPA	ΔPB	ΔPC	ΔPD
APU ON	+25	-121	+121	+60	-180	0	+20	+121
L/O	+180±60	-121±45	+304±12	-242±18	±10	-15±10	0±10	-15±10
MECO	+242±60	0±121	182±40	-363±45	+130	-100	+121	-304

FIGURE 2

10.4

4.1.38

COAS

A. Performance:

The coas performance, in general, was good. As far as instrument accuracy, the result was only a $.09^{\circ}$ Delta between the STS-2 calibration vector and that of STS-1. This repeatability was better than expected. There was only a $.22^{\circ}$ Delta from the I-loaded value (preflight). STS-1 used the same I-load value and demonstrated a similar error. This repeatability indicates that the coas was not harmed by entry or subsequent ascent forces.

1. Analysis of Problems:

The light, used to shine through the instrument and illuminate the reticle on the glass, did not work. The cause of the problem was found, post flight, to be the crew's failure to close the coas circuit breaker. The backup procedure utilizes a flashlight as an alternate light source, however, there was enough reflected sunlight in the crew station at the time of the test to use it for proper illumination.

2. Comparison to STS-1 Data:

<u>Coas Cal (+x) vector</u>	<u>X</u>	<u>Y</u>	<u>Z</u>
STS-1	.93344341	.0037391704	-.18117690
STS-2	.98347002	.002123275	-.18105542

Note: Because of the minimum mission timeline, no alignments with the coas were performed and only the +x was calibrated (against the selected IMU #1) no test of the -z was made.

B. Lessons Learned:

We know that reflected sunlight is also a backup light source for the coas if needed. Other than that, the system performed better than anticipated.

Note:

The only problem noted was because of the crew's failure to close the coas circuit breaker on PNL L4. The PDP calls for the breakers to be closed at 55 min. into flight just prior to on-orbit configuration. The step is somewhat brief and easy to overlook. The step should be made more visible so the next crew will not overlook it.

C. Recommendations for Subsequent Activities

1. LCC limit changes - None
2. FLT rules changes - None
3. SMS/Model changes - None
4. Console or MCC procedure changes - None
5. Data Retrieval Adequacy - None

CONTROLLERS (RHC/THC/RPTA/SCTC)

A. Performance

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 rotational hand controller (RHC) performance was also satisfactory. At no time did the RHCs hinder or distract the crew from performing nominal usage of this system; however, there were two anomalies associated with the PLT RHC + ROLL trim B contact. Both anomalies are explained in more detail in section A.1. (a) and A.1.(b). There were two other anomalies associated with the RHC. One involved the CDR RHC during the November 4 attempt to launch the STS-2 flight. Details are in section A.1.(c). The final anomaly was not directly associated with the flight. It concerned the communication switch on the RHC and is explained in more detail in section A.1.(d). Data to verify anomalies have been requested through building 45 sources. Checks made on December 2 have confirmed that the data will not be available in the near future because of computer problems associated with its processing. The discussion of the anomalies listed below is based upon crew input, operator and engineer interviews, console logs, and available hardcopies.

1. Anomalies

- (a) During on-orbit FCS checkout, controller and switch test, the crew reported that during MAD LOS the PLT RHC + roll trim B contact did not make. Repetition of the same test over a data pass (IDS) showed that the trim B did make contact. Hardcopies of the data on history tab MSK 1546 were taken by the entry control team. Approximate time of intermittent failure is 318:15:26:00. Approximate time of repeat test is 318:15:32:00. Failed parameter is V72K1217X, right RHC + roll trim B. Data has been requested for this period for more extensive analysis. Unfortunately, the super thrift will not be available for this report. Follow up analysis will occur when data is available. For further indications concerning proposed plan to investigate this problem, see the note after A.1.(b).
- (b) During postlanding powerdown, the right RHC + roll trim B contact did make but then failed. Lost of contact was approximately 318:21:32:00. Entry control team was able to confirm lost of contact on the pilot's RHC + roll trim B switch. Data has been requested for further confirmation of his intermittent failure. The note below explain a contemplated plan of action for the pilot's RHC investigation. This anomaly was similar to the one reported during the self-test period as described in section A.1.(a).

Note: Conversation with Lee Bartow (Rockwell) indicates that pilot's RHC will be checked out for intermittent contacts on all positions of the "coolie hat." It will be replaced, if necessary. Testing will begin after data analysis is complete (approximately December 4, 1981).

- (c) No anomalies were noted during the flight on the CDR's RHC; however, the problem resulting from the blow to the RHC on the November 4 launch attempt will generate an investigation. Recall that the RHC stuck at 1.14⁰ out of detent after a sharp blow to the RHC. Initial

thoughts were that either a broken piece of the RHC became lodged in the sissor mechanism, or that the boot and wire support may have been struck so that the RHC was held out of detent by both. Rockwell will test the CDR's RHC on the vehicle. The decision to remove the RHC for further analysis will be made after the test results are final. Initial reaction is not to replace the RHC unless a problem is isolated during testing.

- (d) The final anomaly did not affect this mission, but will affect Orbiter turnaround for the next mission. There is a suspected generic problem with the communication switch on the RHC which does not allow dual redundant contact. Lack of a second weld on the contact bar allowed dislocation of the B contact. Procedures are in being to inspect all three RHCs on "Columbia." Presently, the system specification indicates a need for only one weld, while the system drawings indicate two welds. If the inspection on the vehicle indicates a need for two welds, corrective action will be taken. The problem was first identified on the FSL/SMS RHC.

2. STS-1 vs STS-2

It is difficult to compare data from the two flights since the STS-2 data is not available for comparison purposes. However, after reviewing the STS-1 post mission report and available STS-2 information, the controllers worked as expected through both flight. 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. By the same token, when controller power switches were turned on, the THC could cause transient jet fire commands. Between flight the on-orbit deadband value (H_2) was expanded from 3.25° (.5745v) to 4.29° (.9v). The crew has reported after the second flight that there were commanded jet firings during trans DAP operation only. Nominally, there should be no controller power switch operations during trans DAP, but evidently there were some on STS-2. Since only the on-orbit DAP limits were changed between flights, power switch transients were expected to fire jets during trans DAP operations. Rockwell is working the problem with Honeywell, and will request a design change before STS-3. A limit expansion for the trans DAP similar to the correction for the on-orbit DAP is being resisted by the RCS community.

B. Lessons Learned

At this time all anomalies and concerns are associated with either suspected hardware or software problems. As far as what this section can do to enhance system operation and performance is limited to a role of monitoring hardware and software changes made between flight, voicing an opinion on those changes, and being prepared to react to all possible contingencies during a mission.

C. Recommendations

1. LCC limit changes - none.
2. Flight rules changes - none.
3. SMS parameter/model changes - follow up on changes to RHC software design

as a result of the controller power switch cycling during trans DAP operations.

4. Console or MCC procedure changes - none.
5. Data retrieval adequacy - the capability to obtain data post mission needs to be more timely for analysis purposes.

12.3

4.1.42

DEDICATED DISPLAYS

A. Performance

Performance of dedicated displays cannot be evaluated by ground personnel alone since there is no "Feedback" from the displays on TLM. Only the GPC DD's command or drive signals are on TLM. Also on TLM are control words (Flag Bits) for some displays during non ops-8 and for all displays during ops-8.

Crew performed DD checkout during ops-8 at about 318:15:30:43 which consists of a low/high/and flag test. The DD's are driven to Pre-stored valves allowing the crew a quick look at display accuracy.

1. Anomalies

There were no crew reported (Real time during flight), anomalies with DD's. A FDF error was pointed out to FAO regarding the right DDU cb's which are opened in the PDP 1-6 on page 1-17 but are not closed prior to the OHS-3 burn even though ORB OPS C/L on page 8-3 calls for FLT CNTLR PWR (two) -on.

2. In STS-1, the CDR's HSI heading card was reported stuck and later operated correctly during the ops 8 checkout but then stuck again during entry. This STS-1 instrument was found to have a problem with the HSI heading servo motor and was replaced with a new HSI for STS-2. There were no reported problems during STS-2.
3. During post mission de-briefing, crew reported that the accel, Mach/Vel, and EAS tapes appeared to drive slower than normal on the AMI display. This item is being investigated and requires additional information from the crew. It should be noted that the AMI/AVVI's in the SMS do not have the same drive system as the flight hardware and it is possible that the SMS drives at a higher rate. The SPEC min drive rates for the FLT AMI is as follows;

ALPHA	1.5 inch/sec	12.0 deg/sec
Accel	2.2 inch/sec	22.0 fps ² /sec
M/Vel	1.5 inch/sec	375 FPS/sec
EAS	2.2 inch/sec	22.0 Knots/sec

The A'I drive rates in the SMS are as follows;

Alpha	2.0 inch/sec
Accel	3.8 inch/sec
M/Vel	6.8 inch/sec
EAS	7.4 inch/sec

B. Lessons Learned - None

C. Recommendations for Subsequent activities

1. LCC limit changes - None
2. FLT RULES CHANGES

Current FLT rules call-out each LRU such as ADI, AMI, Etc. The FLT rules are being studied with a view toward breaking down each

LRU into each separate display such as ADI, ATT, ADI error
needles, ADI rate pointers Etc.

3. SMS parameter/model changes - None
4. Console or MCC procedure changes - None
5. Data retrieval adequacy - It would be desirable to be able to enter a history data base and present a display (Plot) of selected parameters from a flight controller console as soon as data is stored into the data base.

IMU

A. PERFORMANCE

With the exception of some abnormal drift characteristics in IMU 3, the IMUs performed very well. The units installed in slots 1, 2, and 3, respectively were S/N 18, S/N 11, and S/N 12.

During the several weeks prior to launch, IMU 3 had demonstrated higher drift rates than the other two units after preflight calibrations. The drift was generally .07 - .09 deg/hr on the IMU 3 X axis. Launch day was no exception in that drift rates were approximately .06 deg/hr. The first star alignment at 0:03:52:30 did not support the drifts observed since the torquing angles were relatively small (see table), and the total platform drift was approximately .03 deg/hr. The platform drift was evidently varying, and in fact this characteristic was observed. Thirty minutes after the first star alignment, the relative misalignment between IMU 3, and the other two platforms was .1 deg, which equates to a drift of .2 deg/hr (10 sigma). The drift, however, settled to a value of .05 deg/hr, and remained at that value. The fact that the drift varied, however, was very peculiar and to date is unexplainable. The relatively high drift rates seen in IMU 3 during preflight appear to be due to a heading sensitivity problem about the UP axis when the platform is in the launch orientation with respect to the NWU coordinate frame. E&D is studying the possibility of including a heading sensitivity term on the UP axis in the calibration routines. The fact that the drift varied for the first few hours of flight then stabilized leads one to believe there is some characteristic of IMU 3 (S/N 12) that requires longer to settle than IMUs 1 or 2. It is possible that the thermal stabilization, which greatly affects gyro drift, has a longer period for S/N 12. Currently, Cape procedures call for 24 hours of warm up for the IMUs prior to launch. IMU 3 possibly requires 36 hours or more warm up to give optimum performance. For the remainder of OFT or until IMU 3 is changed to a different unit, the same high drifts are likely to occur.

The table below summarizes the torquing angles (in deg) for the six star alignments accomplished during the mission.

TIME (MET)	IMU 1			IMU 2			IMU 3		
	X	Y	Z	X	Y	Z	X	Y	Z
0:03:52:30	-.10	.06	.08	-.04	.14	.03	-.11	.06	-.08
0:11:20:30	.05	.05	-.11	-.25	.01	.00	-.10	.14	-.26 *
0:21:58:00	-.01	-.02	.05	-.11	.00	.06	-.10	.18	-.46 **
1:12:45:00	.03	-.05	.08	-.19	-.07	.10	.02	.06	-.04
1:21:55:00	-.04	.00	.11	-.20	.09	-.00	-.02	.10	-.09 ***
2:03:22:47	.01	.00	.08	.00	-.03	.02	.03	-.02	.03

- * Gyro bias for IMUs 1 and 2 updated at 0:12:50:15
- ** IMU 3 gyro bias updated at 0:22:53:45
- *** IMU 2 X-axis gyro bias updated at 2:00:48:00

After each alignment following the first, the HP 9845 program was run to compute new gyro biases for possible uplink, if required. The above table annotates when the uplinks were made, and which IMUs were affected. The table below shows a portion of the output of the program, the uncompensated bias in deg/hr.

ALIGN TIME (MET)	IMU 1			IMU 2			IMU 3			
	X	Y	Z	X	Y	Z	X	Y	Z	
0:11:20:30	-.007	-.007	.015	.033	-.001	.000	.013	-.019	.035	*
0:21:58:00	.001	.002	-.005	.010	.000	-.006	.009	-.017	.043	**
1:12:45:00	-.002	.003	-.005	.013	.005	-.007	-.001	-.004	.003	
1:21:55:00	.004	.000	-.012	.022	-.010	.000	.002	-.011	.010	***

(Asterisks correspond to explanations in table of torquing angles)

Due to the varying drifts observed on IMU 3, IMUs 1 and 2 were the only platforms to receive a gyro bias update after the second star alignment. After calculating the uncompensated drift for two successive alignments, though, the drift seemed to settle, and therefore IMU 3 gyro bias was updated after the third star alignment. After all three platforms had been updated, the drifts were extremely small, the largest being the IMU 2 X-axis, which was slightly greater than one sigma. The gyro bias for that axis was updated for entry.

IMU accelerometers also performed flawlessly. Throughout the flight all accelerometers were indicating a bias of less than one sigma, which is 50 µg. Two offline accelerometer calibrations were run and the uncompensated biases are shown below.

TIME (MET)	IMU 1			IMU 2			IMU 3		
	X	Y	Z	X	Y	Z	X	Y	Z
0:15:50:00	13.34	6.60	-1.25	-32.06	27.81	16.48	-11.97	-.55	17.58
1:1:20:00	13.06	5.01	-4.59	-31.82	24.76	14.90	-11.15	-2.66	17.98 *

* Uplinked biases to all IMUs

After the new biases were uplinked, the accelerometers indicated biases of <10 µg, which verifies the new calibration technique (i.e., no special call out in the CAP, no free drift, etc.).

4.1.46

1. Problem Analysis

a. IMU BITE/T Messages on all Three IMUs at MECO

The message was generated by a redundant rate fail, which is a software aided BITE failure. The redundant rate BITE test was designed to detect platform motion using the rate outputs of the redundant gyro, which is mounted in the X-Y plane of the platform. Nominally, the platform rate is near zero deg/hr; however, certain platform failure modes may cause platform motion, thereby violating the BITE threshold. For STS-1, the threshold was 1.25 deg/hr, but for STS-2 the threshold was lowered to .7 deg/hr. Post-flight review of the redundant gyro data indicates that the platforms actually sensed a rate greater than .7 deg/hr, which authenticates the BITE indications. The most plausible explanation of the platform motion relates to vehicle dynamics at MECO. When MECO occurred, the vehicle underwent an instantaneous deceleration which was sensed by the IMU. Since the gimbals are not perfectly balanced, they reacted to the deceleration, and slightly disturbed the platform for a few milliseconds. The redundant gyro sensed the disturbance, the software tested it against the threshold, and the BITE failure was annunciated. The same failure did not occur on STS-1 due to the higher threshold and less dynamics on the vehicle at MECO. To prevent reoccurrence of the BITEs on future flights, E&D is proposing a CR to change a time constant in the filter which smoothes redundant gyro data. By decreasing the time constant, the spikes at MECO will be lowered below the threshold, while still maintaining the intended purpose of the redundant gyro monitor. The current feeling is that the BITE threshold was proper, but the filter needed to be "tuned;" therefore, the filter time constant will likely be changed but the threshold will remain the same (.7 deg/hr).

- b. After the flight, a delog of IMU downlisted parameters revealed exponential overflows for several seconds. The parameters involved were the downlisted REFSMMATS and the downlisted quaternions which describe the relationship between the IMU outer roll gimbal and the stable member (platform). Since these parameters are all pieces of transformation devices the value of the parameters should never be >1.0. The delog showed several instances of the parameter values growing to 10^{19} or greater, which is obviously grossly in error. Since the parameters are downlisted only and not in-house computations, the error occurs in the onboard software, in the telemetry, or in the MOC processing of the telemetry stream. Conversations with Ground Data Systems (FS) personnel indicate that the problem is known and is due to onboard conversions of floating point numbers. Any parameter that is a floating point number is susceptible and, in fact, the same problem has been observed in simulations. FS personnel are convinced that this is not a ground problem, but is due to either the onboard telemetry system or the flight software prior to the parameter reaching the telemetry system. Fortunately, the problem occurred on a data playback for this flight, but it could have occurred in realtime as well. The impact to the IMU computations would, of course, be overwhelming. The parameters that were affected are used to make IMU "health" calls. Errors of orders of magnitude would naturally invalidate those comps and possibly cause some incorrect calls. FS personnel have talked to IBM about the problem, but IBM considered the chances of occurrence remote; therefore,

no steps are being taken by IBM or FS to fix the problem.

2. Comparison of STS-1 and STS-2 Data

IMU 3 was changed out between flights so caution must be exercised in making comparisons of flight data for that IMU. Other changes which occurred between flights were the frequency of the alignments (2 per day for STS-2 vs 3 per day for STS-1), and the method of performing accelerometer calibrations. On STS-1, the calcs were scheduled in the timeline, the crew had to mode to free drift, and no vents could be occurring. On STS-2, the calcs weren't scheduled and data was normally gathered over one revolution to average out the effects of jet firings.

After gyro bias updates had been made to all three IMUs on STS-1, the largest uncompensated gyro bias was $-.018$ deg/hr on the IMU 3 X-axis. Given the same conditions on STS-2, the largest uncompensated bias was $.022$ deg/hr on the IMU 2 X-axis. On both flights, then, the IMU attitude channels worked very well.

The accelerometers were also well behaved for both flights. The largest uncompensated bias after the first uplink was -15 μ g on the IMU 1 Z-axis.

Both accelerometers and gyros required updating on both flights, but after the updates, the IMUs performed better than anticipated.

B. LESSONS LEARNED

There is a good possibility that the IMUs are being examined too closely. The past two flights have demonstrated that the IMUs exhibit some long period drift characteristics which are unknown at this point; however, they are also performing within spec when the long period effects are given time to settle. The cause of the drifts may be heading sensitivity, thermal effects, or some other error source that is not modelled, but the result is that the IMUs are quite possibly updated too frequently. It may be that $.01$ to $.02$ deg/hr drift is the optimum performance for the hardware and the IMUs should not be updated if the drift computations reveal lower numbers. The misalignments between IMUs are in the process of being computed and plotted to try to model the long term drift; however, data retrieval is difficult due to thrift constraints. The goal is to plot the first 24 hours of flight, but due to data dropouts, and lack of data during LOS periods, the goal might not be realized.

C. RECOMMENDATIONS FOR SUBSEQUENT FLIGHTS

1. LCC LIMIT CHANGES - None
2. FLIGHT RULE CHANGES - Flight Rule 8-34 C.5. Delete the sentence which reads, "any bias measured by comparing successive IMU alignments will be compensated." This deletion is in concert with the explanation in the "Lessons Learned" section of this report.
3. SMS CHANGES - None
4. Console Procedure Changes - As previously stated, the IMUs should be updated (on a per axis basis) only if the uncompensated drift rates exceed $.01$ -. 02 deg/hr. The accelerometer bias methodology worked well and the same procedure should be continued.

14.4

4.1.48

5. Data Retrieval Adequacy - The quality of the hardcopies of MCC displays further complicates post flight analysis. Some hardcopies are totally unreadable while others are so blurry that only pieces of the data are distinguishable. A hardcopy method similar to the MER would be extremely valuable in both realtime and post flight analysis.

14.5

4.1.49

A. Performance

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

MLS AZ + (deg)	LOW	HIGH	ACTUAL
MLS AZ + (deg)	+2.90	+3.10	+3.00
AZ + (deg)	-3.10	-2.90	-3.00
RANGE (NM)	+15.0	+15.4	+15.3
ELEVATION (deg)	+ 5.9	+ 6.1	+ 6.0

During the entry phase, the MLS's were turned on later than the checklist specifies. Although they were turned off due to the powerdown, they should have been turned back on prior to the first AOS pass following balckout. An I/O reset was performed about 11 minutes later to bring the MLS into the GPC read chain.

Range data began locking on around 12.8 nm. Elevation and azimuth began locking on within the next 20 seconds. All three MLS had achieved lock-on of all parameters just outside a range of 12.4 nm. There were several transient data cycles where at least one of the MLS had data declared invalid. This does not pose a problem as the selection filter is used to keep the invalid data from perturbing navigation state.

This type of transient data lock-on did occur on STS-1; however, it was not asnoticeable on the ground. During STS-1, range data achieved solid lock-on at 12.8 nm also. Azimuth locked on earlier than STS-2 (at 12.7 nm). All three MLS's locked on solidly in elevation at the same time as STS-2, at a range of 12.4 nm.

B. Lessons Learned

The MLS does not necessarily achieve simultaneous solid lock-on. We may expect to see several data cycles where the hardware may momentarily lose lock.

C. Recommendations

1. LCC limit chages: None - no LCCS addressed concerning MSL.
2. Flight rules changes: None.
3. SMS/Model changes: MLS need not be modeled to provide simultaneous and solid lock-on.
4. Console/MCC procedure changes: None.
5. Data retrieval adequacy: Although most of the MLS data was available, there were several short dropouts in the thrift data which may have been critical had a problem existed. The entry data was not complete as the final eleven seconds, through landing, were not available on post mission thrift requests.

A. Performance

The prelaunch gimbal test was of primary importance because of the degraded performance in the right pitch secondary actuator witnessed on November 4. That prelaunch gimbal check showed a 3.87 degree/sec drive rate at the start, and then decreasing to a rate well below spec at a non-linear rate indicating that the motor was hesitating as it tried to drive. The delta between the extend and retract rates was greater than one degree, which violated a mission rule until it was decided to change the rule to read a difference of 1 deg/sec between the present and previous gimbal check drive rates. Rockwell decided this was a more realistic approach and they could fly with it. However, this did not address the non-linearity issue, but that was known to be caused by a problem in the synchro which was already manifest and subsequent gimbal checks were monitored for this phenomena.

The second prelaunch gimbal check was performed approximately 6 hours 45 minutes before launch (316:08:24:00 GMT) during the orbit team's prelaunch support. The check went better than expected since the right pitch secondary performed nominally as did the other actuators. The largest delta between the previous gimbal check (November 4) and this one was .17 deg/sec. It should be noted here that this gimbal check is different from those done on-orbit in that it moves one actuator at a time with 8.5 sec between commands. The sequence is LOMS yaw secondary, then primary, LOMS pitch secondary, then primary, followed by the right engine actuator in the same order.

Phase 1 Ascent

During ascent the OMS gimbal positions were recorded on the aero stripchart recorders to detect any shifts in position $>3^{\circ}$. There is a mission rule that no-go's an engine for a burn if it has moved more than 3° from its prelaunch configuration. The stripcharts showed the gimbals nice and steady and from super thrift was seen a $.4^{\circ}$ delta which is equal to one PCM count so the gimbals looked okay.

OMS 1 Burn

Upon transitioning to MM104 the OMS are commanded to their OMS 1 trim positions (see fig. 1) 1 minute 30 sec before ignition. The OMS_IGNITION_COMMANDERED flag also commands the MPS LH₂ dump out the fill and drain valve on the port side above the wing. It starts at a thrust of 90 pounds for about 12 sec., and then decreases to a negligible amount. However, in this 12 sec., a minus yaw error from the plus Y thrust, and a plus pitch along with a minus roll error from the plume impingement on the wing, are generated. This happened on STS-1 and was unexpected then, but not new this time.

Five seconds into the burn the OMS TVC compensates for these errors by commanding the engines to new trim values (see figure 1). Left pitch is commanded from $.31^{\circ}$ to 5.62° in 1 sec ($5.31^{\circ}/s$), left yaw remains steady, right pitch goes from 0° to -5.86° in 5 sec., ($1.17^{\circ}/s$), and right yaw goes from -6.03° to -1° in 2.5 sec ($2.01^{\circ}/s$).

The left pitch moves 5X as fast as the right pitch and yaw so that it sits at 5.62° for 5 sec while the right pitch and yaw reach -5.86° , and -1° in that 5 sec., and then they all return to their initial positions simultaneously as the errors are taken out.

The stripcharts show the roll, pitch, and yaw errors and rates as a result of the MPS LH₂ dump and the corresponding gimbal positions.

The remainder of the burn was nominal lasting 83 sec., achieving a delta V of 146 fps and an orbit of 54/120.

Post OMS 1 Gimbal Check

Executed at 20M 11S MET (8M 15S after OMS 1) this was the first on-orbit gimbal check and proved to be nominal. As was said before, the gimbal checks done on-orbit are different from the prelaunch. This procedure moves all four actuators simultaneously in secondary first and then primary. It is done by item entry on the XXXXXMNVRYYYYY display.

The largest delta from the previous gimbal check was $.47^{\circ}$ in left yaw primary extend, but this was a faster rate, and therefore of no concern. The right pitch secondary retract improved $.39^{\circ}$ which was good to see. There is a theory that the differences in configuration and gimbal checks prelaunch and on-orbit might have something to do with the discrepancy in gimbal rates. Prelaunch the gimbals are working against gravity and needless to say on-orbit they aren't.

It should be noted that the SCR's are run at 10 mm/sec to gain a greater degree of accuracy on the drive rates. This was done for all gimbal checks but only on two recorders. The remainder of the recorders were run at normal speed (1 mm/sec). The primary position feedback is received at 5 samples/sec and the secondary at 1 sample/sec. With the results of this gimbal check the GO was given for OMS 2.

OMS 2

Fifteen seconds before OMS 2 ignition the gimbals were commanded to the trim positions loaded by the crew.

OMS 2 ignition occurred at 41:51 MET. At the beginning of the burn there was a 3.3° pitch error, a $-.5^{\circ}$ yaw error, and a 1.6° roll error. These errors are due to desired and actual burn attitude. TVC takes care of these errors immediately by commanding left pitch to 2.85, left yaw to -5.69, right pitch to 5.02, and right yaw to 4.85. This maneuver takes 2.5 seconds, and then the gimbals return to their former positions.

OMS 2 was a 73 sec burn resulting in a delta V of 122 fps and an orbit of 120/120. The entire burn was nominal.

Post OMS 2 Gimbal Check

This gimbal check was executed one minute after OMS 2 cutoff and was almost a carbon copy of post OMS 1. Largest delta was .42 in left yaw primary

extend which is back to normal for this actuator. No anomalies were found.

OMS 3 A & B

OMS 3 was delayed one orbit due to fuel cell problems. OMS 3 was scheduled for 6:20:43 MET and fuel cell 1 was shutdown at 5H3M MET.

OMS 3A ignition occurred at 7H45M MET. It was a single engine burn using the left engine. The crew loaded trim values were left and right pitch .4, left yaw 5.1, and right yaw the same as OMS 2.

There was a $+2^{\circ}$ yaw error at ignition that went to $+3.2^{\circ}$ and a 3.6° pitch error that went to 4.8° . Again this is the difference between desired and actual attitude and the fact that a single engine burn will give some attitude error.

Duration time of 12 sec gave a delta V of 10.4 fps and an orbit of 120/127. Nominal burn.

OMS 3B was also a left engine burn with the same trim values, igniting 4 minutes after OMS 3A and burning for 24 sec. Its delta V was 21 fps and final orbit 120/139. The yaw error went from zero to -3.2° and the pitch error from zero to 5.7° . It has not been verified at the time of this writing, but the errors seem to be taken out by jet firings.

Both burns were nominal.

OMS 4

This burn was a single engine right occurring at 8:33:20 MET (43M 41S after completion of OMS 3), and lasting 39 sec. Trim values were, for left and right pitch .4, left yaw same as OMS 3 (no input), and right yaw -5.1° .

The delta V achieved was 34.4 fps resulting in an orbit of 139/140. There was a slight rise in P_c 22 sec into the burn which was not seen in any of the other burns.

At ignition there was a $+2^{\circ}$ pitch error which was down to $+0.5^{\circ}$ by the end of the burn. The yaw error went from 0° to 1° during the burn, and then gradually went negative. This is probably due to jet firings at the end of the burn to attain the correct attitude, but this has not been verified yet due to incomplete data (superthrift has not been received as of this writing).

Post OMS 4 Gimbal Check

Performed at 8H36M52S MET the gimbal check looked good. Max delta was $.24^{\circ}/s$ for left yaw secondary retract which shows that no three gimbal checks are alike.

Pre-deorbit Gimbal Check

The final gimbal check was executed at 318:20:02:42 GMT (2D04H52M42S MET), 21 minutes before the deorbit burn and everything was go. Max delta for this one was $.50^{\circ}/s$ in left yaw secondary extend.

Deorbit Burn

Ignition occurred at 318:20:23:15 GMT which was during LOS so the only way of knowing it was successful as of this writing is that it accomplished its objective. Duration time was 175 sec and delta V achieved was 313.4 fps.

As for all the other burns, super thrift has been requested. It's just a matter of receiving it.

1. Anomalies

There were no anomalies during the mission. The gimbal checks were of prime importance, and a repeat of the non-linear rate seen in the right pitch secondary retract during the November 4 launch attempt was looked for. This behavior was not seen again. All the gimbal checks were nominal, adhering well to the new mission rule of a delta less than 1. deg/second from the previous gimbal check.

The attitude errors present at the beginning of the burns are due to the Orbiter being off a few degrees from the desired burn attitude, but this is quickly taken care of by the OMS and RCS.

The pressure drop in OMS 4 is a result of a mid-burn crossfeed which was part of FTO 242-03.

Due to fuel cell 1 being shutdown the post OMS 3 gimbal check was sacrificed to save power. The gimbal checks use 182 watts per actuator and it takes 20 sec., each for primary and secondary. Since OMS 3 was nominal it was decided to forego the gimbal check. However, a post OMS 4 gimbal check was held to be mandatory as well as the pre-deorbit gimbal check.

2. Comparison of STS-1 and STS-2

During STS-1, the right OMS pitch actuator locked-up at the null position during OMS 2. This was a result of the rotor and stator in the synchro coming in contact with each other. The right primary pitch was subsequently failed during the OMS 3 gimbal check.

This problem of the rotor and stator coming in contact with each other is due to side loading imposed on the synchro and too small a clearance between the rotor and stator. Two MCR's are in work to change the clearance from .001 to .003 and also to redesign the synchro drive pins to provide positive retention, a new single piece motor end bell to eliminate slack, and a new double-dog coupler for more balance between shafts.

These changes will not be implemented until STS-5 so the potential for this problem to occur again is still there.

However, the synchros performed well during STS-2 and hopefully will continue to do so.

STS-5 will have the hardware changes included in the mini-mod.

OMS 3 for STS-2 was done in two segments, A and B, as opposed to STS-1. This was an FTO required to demonstrate the capability of the OMS engines to restart under zero g and hard vacuum conditions with a minimum length of time between burns.

OMS 4 accomplished part of FTO 242-01 verifying procedures, sequencing, and dynamic response of the OMS crossfeed system during switchover from one pod to another.

B. Lessons Learned

As a result of the problem experienced on the November 4 launch attempt, the stripchart recorders were run at 10 mm/sec during the gimbal checks to obtain greater accuracy in determining the rates. This way a delta greater than 1 degree from the previous could be seen in less time in order to go-no/go the burns.

Super thrift was ordered for all gimbal checks as they occurred.

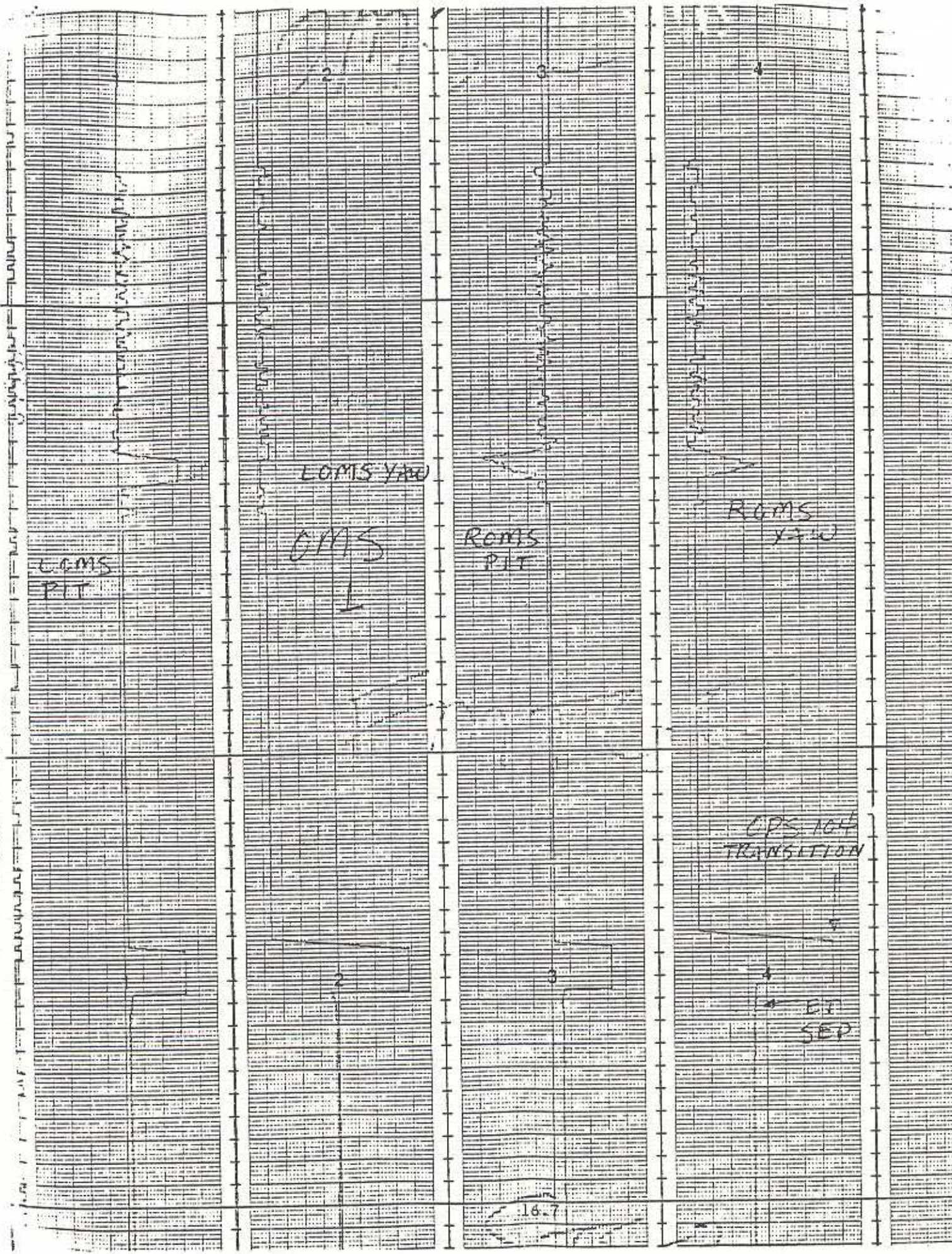
C. Recommendations

1. No changes are necessary in the launch commit criteria limits. These did not pose any problems.
2. The mission rules have already been changed due to the actuator anomaly on November 4, and this change has been mentioned earlier in this report.
3. As far as SMS parameter and model changes, the OMS is pretty good except for the MPS LH₂ dump that occurs simultaneously with OMS 1. This is not seen in simulations.
4. A procedure change that has been incorporated was to run two SCR's at 10 mm/sec during gimbal checks and recording the rates in a table for quick comparison to the previous gimbal check. Ordering super thrift has become a normal procedure also.
5. Data retrieval obviously leaves something to be desired. It is very frustrating to write a report with incomplete data. Super thrift for this subsystem was ordered the week of November 16 and as of November 30 has not yet been received.

STS-2 EVENT TIMES	GMT
PRELAUNCH GIMBAL CHECK	316:08:24:00
LIFTOFF	316:15:10:00
OMS 1	316:15:20:33
POST OMS 1 GIMBAL CHECK	316:15:30:11
OMS 2	316:15:51:51
POST OMS 2 GIMBAL CHECK	316:15:54:04
OMS 3A	316:22:55:03
OMS 3B	316:22:59:15
OMS 4	316:23:43:21
POST OMS 4 GIMBAL CHECK	316:23:46:52
PRE-DEORBIT GIMBAL CHECK	318:20:02:42
DEORBIT BURN	318:20:23:15

16.6
TABLE 1

4.1.56



4.1.57

OMS L

LOMS PIC

ROMS PC

IGNITION

ROLL RT

~~ROLL~~ YAW RT

RT DEP

RADAR ALTIMETER

A. Performance

Performance evaluation during the OPS 8 checkout showed no bias errors as all data fell within the specified self-test limits. The self-test range for RA data is 900 to 1100 ft. The actual values seen during self-test were 1009 ft for RA1 and 1002 ft for RA2.

Both radar altimeters locked on slightly above 5000 ft in altitude (5002', 5010'). This is the maximum range of the hardware itself. STS-1 performance showed lock-on to occur about 250' earlier. All data during entry for STS-2 remained valid throughout the duration of available data. Eleven seconds prior to landing all data on thrift went static. We were not able to retrieve the critical time period during which the nose gear was lowered. Therefore, no comparison can be made to the performance exhibited on STS-1 where the RA locked on to the nose gear.

B. Lessons Learned

Whether the RA locked onto the nose gear during this flight is somewhat academic in relation to future flights. There are currently several changes being made to the RA for STS-3 and subsequent flights, which should reduce the possibility of locking on to the nose gear.

C. Recommendations

1. LCC Limit Changes: None - no LCCS addressed concerning RA
2. Flight Rules Changes: Not applicable as there are no requirements for RA for entry. The data only drive a crew display.
3. SMS/Model Changes: None - the hardware changes being made will be transparent to the SMS model.
4. Console/MCC Procedure Changes: no procedures required.
5. Data Retrieval Adequacy: The data retrieval system was inadequate to support evaluation of the RA. The last eleven seconds of mission data are required to analyze and compare the performance of the RA to the performance on STS-1.

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 1, and in the SODB, volume 1, table 3.4.5.1-2.

STS-2 OPS 8 RGA SELF TEST DATA

RGA	ROLL BIAS	LIMITS	PITCH BIAS	LIMITS	YAW BIAS	LIMITS
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	-0.04	0.00±0.19	-0.04	0.00±0.19
3	-0.08	0.00±0.35	0.00	0.00±0.19	-0.04	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 DATA	LIMITS	PITCH DATA	LIMITS	YAW DATA	LIMITS
1	20.16	+20.0±1.12	10.08	+10.0±0.56	10.16	+10.0±0.56
2	20.07	+20.0±1.12	10.08	+10.0±0.56	10.12	+10.0±0.56
3	19.91	+20.0±1.12	10.04	+10.0±0.56	9.96	+10.0±0.56
4	19.68	+20.0±1.12	9.92	+10.0±0.56	9.92	+10.0±0.56

RGA LOW TEST	ROLL DATA	LIMITS	PITCH DATA	LIMITS	YAW DATA	LIMITS
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	-20.08	-20.0±1.12	-10.12	-10.0±0.56	-10.04	-10.0±0.56
4	-20.16	-20.0±1.12	-10.04	-10.0±0.56	-10.04	-10.0±0.56

1. No problems were noted.
2. The STS-2 ORBITER RGA performance and data reviewed were comparable to STS-1.
3. System operation and performance was nominal. There are no recommendation to enhance vehicle or ground system operations.

C. Recommendation

1. No LCC limit changes recommended.
2. Flight rule changes are not recommended.
3. Recommend they add to OPS 8 an RGA motor failure (NO SPIN) capability.
4. No new console or MCC procedures recommended.
5. In general, data retrieval was adequate. Post mission data retrieval delays system evaluation.

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. STS-2 SRB RGA performance and data was comparable to STS-1.

B. Nothing was noted in the system performance which would require change in system operation.

C. There are no recommendations for changes in support systems or procedures.

1. LCC LIMIT CHANGES - NONE
2. FLIGHT RULE CHANGES - NONE
3. SMS CHANGES - NONE
4. CONSOLE CHANGES - NONE
5. DATA RETRIEVAL - ADEQUATE

RCS REACTION JET DRIVERS

A. Performance

The RJD's were modified for STS-2 such that primary and vernier driver power could be controlled separately. The new capability worked well during the mission with the only anomaly being a procedural error.

1. Problem Analysis

The only problem encountered occurred during the OPS 8 RCS driver test when the crew failed to turn off the vernier driver power prior to executing the test. With driver power on the test declares the jets failed. The crew repeated the test without resetting the RCS RM failure counters. RM then declared the jets failed. The crew then had to clear all the failures and re-select the deselected jets. This problem was caused by the SMS not being properly configured for the majority of the STS-2 simulations, requiring the crews to use an incorrect procedure.

2. The STS-1 and STS-2 data compared in an identical fashion.

B. Lessons Learned

In addition to the obvious lessons learned, emphasis should be placed on the Flight Data File where training and mission procedures are not identical.

C. Recommendations

1. LCC Limit Changes - none.
2. Flight Rule Changes - none.
3. SMS Parameter/Model Changes - the SMS RCS model DR's should not forever be ignored.
4. Console or MCC Procedure Changes - none.
5. Data Retrieval Adequacy - the thrift system needs a massive rework. There are cases when attempting to analyze a single event requires working with 40-50 pages of microfiche.

Star Tracker

A. Performance

The -Y and -Z star trackers performed nominally. Once at alignment attitude the crew reported the star data was immediately accepted after moding to star track. The SMS models this much slower.

At the 11:20:30 (PET) alignment ang err which is the angle difference between star sightings as measured by the star trackers and the actual angle between the stars in the star catalogue was 0.00 degrees. All other alignments showed ang err to be 0.01 degrees. Alignment verification as shown immediately after align complete, and reacquisition of stars in the table to be highly consistent with the expected accuarcy of 100 $\overline{\text{secs}}$ or .02 degrees.

Star tracker threshold level verification (FTO-273-07) results are as follows:

<u>TIME (PET)</u>	<u>-Y</u>	<u>-Z</u>	<u>S TRK THOLD</u>
0:21:40:00		17	3
1:22:00:00	21	17	3

Some question of validity of this FTO is of concern to the engineering community because the procedure is not clear as to when the crew inputs the thresholds and modes to star track. Recommend first to set threshold and subsequently mode to star track, so that a break track will be issued forcing the star tracker to reacquire the stars.

The crew recorded star tracker door open times at 0:02:40:00 (PET) to be less than 5 seconds for both trackers. With two motors driving this is a nominal time period.

1. Anomalies

The star tracker anomaly status can be broken down into two categories:

a. Onboard

- (1) Target suppress on star trackers
- (2) Spurious bites on star trackers

b. Ground

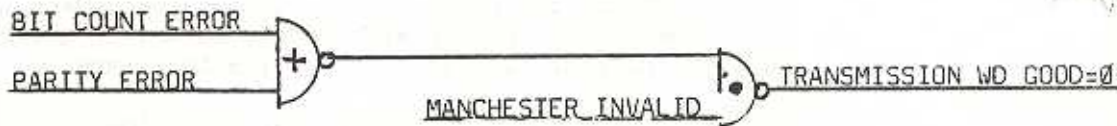
- (1) Cal curve problem on star tracker H&V data

- (a) The target suppress circuit in the star tracker hardware kept the shutters closed approximately 80 percent of the time. The -Y star tracker procedurally remains powered throughout the flight and because of the target suppress logic closing the shutters, only one star of opportunity was acquired in the entire mission. Apparently when crossing the earth's terminator from light to dark or vice versa the target suppress logic is triggered before the Bright Object Sensor (BOS), thereby closing the shutters. The crew before every alignment had to manually open the shutters to unlatch the target suppress logic.

The -Z star tracker issued at three different times a "G22 STAR TRKR" fault summary message (FSM). The star tracker executive in the flight software "OR's" the transmission word going to the star tracker from the FF1 MDM, and the fail discrete and issues a class 3 alarm and the FSM. A class 3 alarm involves a blue light (SM alert) on PNL F7 and a tone. The signals that make up the transmission word are:

- (1) Manchester invalid
- (2) Bit count error
- (3) Parity error

Mechanization of these bites in the star tracker hardware is as follows:



Manchester invalid is a circuit in the star tracker interface adapter that checks for change of state, from high to low or vice versa of the the command word for at least once per microsecond. If this does not occur, the command word for this cycle is disregarded by the star tracker.

Parity error is a circuit in the star tracker hardware that checks to see if the number of bits in the command word is odd. If the number of bits going to the star tracker is even a parity error is detected by the bite logic.

Bit count error is a circuit in the star tracker hardware that checks to see if these are 16 data bits plus, 1 sync bit, plus 1 parity bit going to the star tracker. If the number of bits does not equal 18, a bit count error is detected by the bite logic.

Review of the flight data on the star trackers, clearly shows a manchester invalid signal triggering the bite and subsequently the FSM. The OGMT's that account for the manchester invalid and FSM's are as follows:

- (1) 316:18:27:19:22
- (2) 318:12:58:57:13

* (3) 318:05:49:21:15

* Only one FSM was issued at this time; however, in reviewing the data manchester invalid was also detected at:

(4) 318:05:49:41:5
(5) 318:05:49:53:9

There was no FSM issued. The reason for no FSM is that the crew acknowledged the first message and therefore inhibited the FSM from reoccurring.

There has been no explanation given for the cause of this bite. Ball Brothers, vendor of the star trackers has been contacted on this issue and is coordinating their analysis with E&D. There was no data degradation as far as we know as a result of these bites.

- (b) The calibration curve in the MCC has a 0.2° bias on the H&V data. The parameters affected are V71H5041B, 5541B, 5061B, 5561B. Reviewing the MCC polynomial coefficients for the data shows the A_0 term to be $-5.0024425E00$, and should be -5.2 . This explains the discrepancy and has been reported to be fixed for STS-3.

2. Comparison of STS-1 and STS-2

The star trackers performed much like STS-1. Ang err in STS-1 for all seven star alignments was 0.01 degrees.

Target suppress inhibited stars of opportunity on both flights. This will not be fixed until release 19 software is implemented.

The major difference between STS-1 and STS-2 star tracker performance was the presence and affect of the manchester invalid bite in the command word to the -Z star tracker. This condition did not exist on STS-1. A comparison between the -Y and -Z star trackers can be done in the area of operating hours. The -Y star tracker shows 502 hours and the -Z shows 360 hours.

B. Lessons Learned

It was requested for STS-2 that the variable downlist contain an address of a software parameter that showed if the crew modes the -Y star tracker-to-star track after an alignment. This parameter was CGYV_TRK_CNTR (1,2) in the star tracker executive that showed not only the term idle status, but star of opportunity logic and data filter execution.

The presence of the manchester invalid bite for less than one second causing a class 3 alarm should be looked at with more scrutiny. This event demonstrates its untimeliness where it could have awoken the crew had they been asleep. Recommend removing bite from issuing a FSM and subsequent class 3 alarms.

If target suppress is going to lock out star of opportunity logic from executing and acquiring stars, there is no requirement to leave trackers powered up as to this just accumulates hours against operating life. On the other hand, if the subsequent on-orbit attitudes reduce the time trackers are exposed to

the earth's terminator, they could be left powered on. It is recommended that this condition be assessed for subsequent flights.

Presently the -Z star tracker is powered at least 10 minutes before any given star alignment. Because the nav base temperature varies between 75^oF and 80^oF the star trackers could experience a 4^oF variation about that temperature, which would be thermally sufficient to accept data and not requiring additional warmup time. Recommend that at star tracker set up the -Z star tracker followed by a GNC I/O reset be performed at that time.

C. Recommendations

1. There are no launch commit criteria violations with the star trackers since they are not required for launch.
2. If it is decided to keep star trackers unpowered because the target suppress will inhibit star of opportunity logic, the flight rules will need to be changed to reflect this change. On page 8-13 power both trackers off for GN2 and GN8, on page 8-14, section B change to read "if no alignments taking place turn both trackers off."
3. The star tracker model in the SMS should be corrected for star tracker acquisition time once at alignment attitude. The crew reported that when star track was moded; it was only a few seconds till the stars appeared in the star table.

A verification of star tracker door open times should be done on the SMS to match real world operations (→ 5 seconds).

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 till release 19 software. The engineering community is presently writing a memo on this issue.

4. Recommend to fix MCC cal curve on the star tracker H&V data. STS-2 showed a .2 degree bias on V71H5041B, 5541B, 5061B, and 5561B.
5. The data retrieval system performed marginal post flight. Twenty percent of the data requested was not received.

SWITCHES

A. Performance

GNC switch performance during all STS-2 OPS was nominal. There are no hardware failures noted at this time although all thrift data has not been secured. There is a discrepancy concerning pitch CSS PBI on panel 07. CDR claims this PBI was depressed simultaneously with R/Y CSS PBI on panel 07 (GMT 318:21:22:4), but flight control did not engage CSS in the pitch axis until CDR moved his RHC sufficiently out of detent. R/Y CSS did engage when CDR depressed that PBI at the time in question. The PBI has three contacts and it seems unlikely that all three contacts would fail--a contact failure would not give a CRT annunciation to the crew. Thrift data has been requested for the three contact discretes and should be following. Also, there was a failure of the PLT RHC +ROLL trim switch which will be covered detail in controllers post flight reprot.

1. Anomalies

Two anomalies are reported in the performance section.

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 - system is unusable for near realtime analysis.

TACAN

A. Performance

Due to fuel cell problems, TACAN's were powered down after OPS 8 self-test with power on scheduled for V = 15 K fps (approximately 3 minutes prior to blackout exit). Initial AOS indicated TACAN's were off; request for TACAN power was made ASAP. (Power up history was as follows: LRU #3 at 162K ft., LRU #2 at 159 K ft., and LRU #1 at 158 K ft.). Following the late power on, selected bearing data was made available to nav at 153 K ft., (as opposed to approximately 160 K ft on STS-1), while selected range data (delayed by a 1 minute internal warmup timer) was available at 145 K ft/239 nm (as opposed to approximately 156 K ft/325 nm on STS-1). As a point of interest, LRU #3 achieved range lock on 46 sec after power on, while LRU #2 and LRU #1 were delayed 65 sec and 62 sec, respectively.

There was no loss of range lock, following initial acquisition (whereas STS-1 had occasional loss of range lock on LRU #1, only).

Bearing performance was extremely good with glitches (multiples of 40°) occurring only sporadically during initial acquisition (as in STS-1), and then only during subsequent cone-of-confusion periods. (During STS-1 TACAN's #1 and #2 exhibited much more noise (40° glitching) while #3 was very stable; #2 actually was declared failed by RM due to a 10 second period of noisy data, without any loss of lock). Frequent nominal loss of lock during STS-2 noisy periods prevented any transient RM actions. It has been suggested that the STS-1 TACAN #2 noise problem can be attributed to signal reflections from a mountain range south of (and parallel to) the STS-1 trajectory, in conjunction with the #2 antenna polarization characteristics during a large bank maneuver. Evidently this specific set of conditions would not necessarily be duplicated within the STS-2 timeline and trajectory.

OPS 8 - TACAN self-test results were well within expected limits.

TACAN	AZIMUTH - DEG	RANGE - NM
(LIMITS)	(177.5 TO 182.5)	(0 TO 0.5)
1	179.5	0.0
2	179.3	0.1
3	179.7	0.0

TACAN #1 azimuth displayed 182.1° approximately 6 seconds into self-test, however, it stabilized to the recorded value within 10 seconds. ($180 \pm 2.5^{\circ}$ represents software limits that would generate arrows; however, $180 \pm 2^{\circ}$ would generate a "BITE" indication from internal self checks. Software range limits are "0 to 0.5 nm" while internal hardware checks values to "0 to 0.2 nm").

B. Lessons Learned

In order to enhance our ability to evaluate OPS 8 self-test results (both

during and post mission) we should request special thrift and D-logs as a normal course of events.

For critical hardcopies, multiple requests should be made, maybe even on different TV monitors (did not receive some critical universal plots hardcopies).

If conditions prohibit us from performing any TACAN DTO's during orbital phase, we might consider turning TACAN's to specific stations during that period of OPS 8 following the TACAN self-test.

C. Recommendations

1. LCC LIMIT CHANGES - STS-2 TACAN subsystem performance does not suggest changes in these areas.
2. FLIGHT RULES CHANGES - STS-2 TACAN subsystem performance does not suggest changes in these areas.
3. SMS PARAMETER/MODEL CHANGES - The nominal lock-on scenario for TACAN's in the SMS is totally unrealistic in comparison to both STS-1 and STS-2, where all units achieved lock-on within seconds of one another. Late lock-on of the third LRU is causing dilemma situations, resulting in subsequent crew action and/or delayed availability of data to nav.
4. CONSOLE OR MCC PROCEDURES - TACAN dilemma situations can only be solved by comparison of each LRU against ground radar computations. A problem exists in the range vs ground computation (timetag) whereby nominal range data disagrees with the ground by approximately 0.8 nm at blackout exit/initial lock-on. An attempt has been made to bias the TACAN timetag during simulations; this effort minimizes these errors during sims, but does not guarantee similar results during missions. MPAD has come up with an algorithm that they feel will eliminate this discrepancy.
5. DATA RETRIEVAL ADEQUACY - It is recommended that special thrift and D-logs be requested immediately following post mission activities; request forms should be prepared pre-mission, except for GMT.

ANOMALY LIST

Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
1 BOOSTER-1	+7:43 ^s	Left SSME GH ₂ out press. Xducer (V41P1260A) failed off-scale low. This failure occurred on STS-1 and was expected to occur on STS-2.	CLOSED 0/14 ^h 00 ^m
2 BOOSTER-2	+ 1:40 ^m ^s	Left SSME POGO Precharge Press FID (failure ID) was set at 1:40 in the controller. This failure occurred on STS-1 and was expected to occur on STS-2.	CLOSED 0/14 ^h 00 ^m
3 BOOSTER-3	+ 2:36 ^m ^s	Left SSME GH ₂ out temp Xducer (V41T1261A) failed off-scale low. This failure occurred on STS-1 and was expected to occur on STS-2.	CLOSED 0/14 ^h 00 ^m
4 GNC-1	+ 10:00 ^m ^s	Transient S/W bites on all 3 IMU's at MECO ("Redundant Rate Fails"). INITIAL ASSESSMENT IS THAT THE RGM g-COMPENSATION ITERATION RATE (6.25 Hz) IS DIFFERENT THAN THAT IN GYRO MASS UNBALANCE COMPENSATION (1.04 Hz); I.E., BITE DUE TO S/W TIMING DELAY, BUT NO FURTHER IMPACT.	CLOSED 0/14 ^h 30 ^m
5 EECOM-1	+ 11:22 ^m ^s	APU3 Temp message. PLT shut down this APU prior to MPS dump complete, but got a good dump. CAUSED BY WATER SPRAY BLR-3 FREEZE-UP. WSB3 HAS THAWED NOW AND APU3 CONSIDERED OK FOR USE.	CLOSED 0/14 ^h 00 ^m

Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
6 EECOM-2 +	12 ^m :32 ^s	Transient EVAP message at MECO. Crew later reported several Master Alarms - Cabin Atm. (at 4MSM & 5H04M). Problem is EVAP PRI A ctrlr. Crew told to select Ctrlr B if Cabin Temp. gets unacceptable. Crew told to switch to PRI B at 5H45M & EECOM keeps lights good at 5H51M. MAY BE CAUSED BY VICING IN STOPPING EVAP.	
7 BOOSTER-4 +	13 ^m :21 ^s	Right SSME Main Oxidizer Valve (MOV) Servo Actuator B FID was set during MPS dump seq. as a result of APU3 shutdown near the end of the dump. With no hyd. press., the MOV will close with pneumatic press. applied. The controller sets the FID at 10% error of cmd. vs. actual position.	CLOSED 0/14 ^m 00 ^m
8 BOOSTER-5	13 ^m :37 ^s	Right SSME fault message (MPS CMDR) was set as a result of R SSME in pneumatic shutdown mode from early APU3 shutdown. The dump terminate seq. cmd is illegal in this mode and the MPS CMD message results.	CLOSED 0/14 ^m 00 ^m
9 PROP-1	13 ^m :38 ^s	R OMS OX gauging biased $\approx 14\%$ high. ←	CLOSED 0/14 ^m 33 ^m
10 EGIL-1	25 ^m :50 ^s	Fuel cell 2 voltage biased $\approx 0.7V$ low, compared to MN B voltage, CONFIRMED XDUCCER BIAS.	CLOSED 0/14 ^m 00 ^m

Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
11 PROP-2	37:25 ^s	L OMS fuel gaging ^{gauging} bad. (Same problem on STS-1). GAUGE LAGS ACTUAL, BUT CATCHES UP WITHIN \approx 60 SECONDS. EXPECTED TO WORK PROPERLY FOR QTY'S \angle 30%. 	CLOSED 0/14 ^h 30 ^m
12 EECOM-3	40 ^m	APU 1 GGVM cooling problem - pump out temp. high. EECOM reported at 1 ^h 49 ^m that temp. peaked at 249°. CONCLUDED THAT HAVE LOST WATER COOLING TO THE GGVM. ALSO, HAVE A GAS BUBBLE IN GGVM.	
13 PROP-3	1:04 ^m	Vernier jet temp (low) problem. Indication on F5L (ox). . . . SLOWER THAN EXPECTED WARMUP. NOT A PROBLEM.	CLOSED 0/14 ^h 00 ^m
14 INCO-1	0 ^d :01 ^h :35 ^m	Cannot get camera D turned on. Camera required at 04 ^h 25 ^m - was due to open CB.	CLOSED 0/04 ^h 25 ^m
15 EGIL-2	0 ^d :02 ^h :27 ^m	Fuel cell 2 O ₂ flow high indication. WILL DO FUEL CELL PURGES IN MANUAL FROM NOW ON, FOR BOTH FC2 AND FC3. NOTE THAT FC1 WAS SHUTDOWN (SEE EGIL-3).	

	Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
16	EGIL-3	0 ^d 02 ^h 27 ^m	Fuel cell 1 PH indication & down arrow. At 00/04 ^h 50 ^m FCI was open circuited per NCC request - not load sharing properly. MNA tied to B first. At 00/05 ^h 05 ^m FCI shut down per MER request (concerned about O ₂ & H ₂ mixing). Resistant valves closed at 00/05 ^h 07 ^m .	
17	GNC-2	0 ^d 04 ^h 44 ^m	IMU#3 excessive attitude error in X & Z axes. Crew told to not do IMU to IMU align if get RM Fail. DID A GOOD ALIGNMENT AND DECIDED TO DESELECT IMU3 FOR SLEEP (1ST NIGHT). AMOUNT OF ERROR SEEMS TO BE DEPENDENT ON ATTITUDE.	
18	DPS-1	00/04 ^h 48 ^m	PLT reported several CRT#12 Poll Failure Messages. PROBLEM CLEARED WHEN CREW CYCLED PWR.	CLOSED 0/14 ^h 00 ^m
19	PROP-4	00/04 ^h 48 ^m	Crew reporting SPEC 87 OMS Trip Thermal Messages. At 00/05 ^h 31 ^m crew told to select UB Htrs. (A Htrs. don't appear) failed but Htr. set point may be set too low). (This pertains to OMS/RES X feed Htrs.) RESET LIMIT VIA TMBU. - NO FURTHER OCCURRENCE	CLOSED 0/14 ^h 00 ^m
20	EECOM-4	00/05 ^h 34 ^m	Crew reported several SPEC 66 H ₂ O Messages. EECOM reported close to hard Fill on Tnk B. Crew told to open inlet to Tnk C. PROCEDURAL PROBLEM.	CLOSED 0/14 ^h 00 ^m

	Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
21	GNC-3	0/2 ^H 34 ^M	COAS PANEL LIGHT NOT ILLUMINATED. USE FLASHLIGHT TO READ COAS PANEL.	
22	EECOM-5		FREON LOOP 1 TEMP ~ 21° HIGHER THAN EXPECTED. ATTITUDE ACCOUNTS FOR ~10°. SUSPECT THE HIGH BETA ANGLE FOR THE REST. WENT TOP-TO-SUN ATTITUDE FROM 2LV, AND LOOP 1 TEMP DECREASED AS EXPECTED, NOT A PROBLEM.	CLOSED 0/14 ^H 00 ^M
23	EGIL-4	0/9 ^H 18 ^M 0/9 ^H 32 ^M	MNC 20-amp SPIKES (TWICE). PAYLOADS SUSPECTS THIS IS NORMAL DURING SIR-A OPS.	CLOSED 0/14 ^H 00 ^M
24	EECOM-6	0/11 ^H 43 ^M	AFTER SUPPLY WATER DUMP, THE SUPPLY H ₂ O DUMP ISOL VLV TB STAYED BP. ON M486B, FOUND CB (MNB SUPPLY H ₂ O DUMP ISOL) POPPED. RESET AND IT STAYED IN. NO SHORT INDICATED.	
25	EECOM-7	0/00 ^H 47 ^S	TEMP. XDUCER (-60 < Y < -110; 460 < Z < 520) FAILED OFF SCALE LOW. LOSS OF 1 BOUNDLINE TEMP.	

	Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
26	PL-1	0/12 ^H 21 ^M	S92 PWR RFL MSG. DUE TO SIR-A OPNS DURING WATER DUMP. CREW REPORTED REFLECTED PWR=9.	CLOSED 0/16 ^H 30 ^M
27	PL-2 (EGIL-5)	0/14 ^H 16 ^M (SLEEP)	UNEXPLAINED RESPONSE TO CIRC PUMP OPNS! CIRC PUMP: <u>ON</u> <u>OFF</u> MNC(MID) 12→4 AMPS 4→12 AMPS PL AFT 5.7→0 AMPS 0→6 THEN 3 AMPS IECM IS OPERATING AT 3 AMPS (PL AFT), BUT NOT SURE WHY IECM IS NOT PULLING 5 AMPS. IMPACT TO CIRC PUMP CYCLE DTO?	
28	EGIL-6	0/14 ^H 40 ^M (SLEEP)	AC3ΦA CURRENT RISE OF 1.5 AMPS FOR 50 SEC THEN BACK TO NORMAL. Due to the food warmer.	Closed
29	PL-3	0/14 ^H 48 ^M (SLEEP)	S92 PWR FWD MSG (IE, TOO MUCH SIR-A FWD PWR). UNEXPLAINED. CURTAILED SIR-A/SMIR.2/OCE DATA TAKES UNTIL SENT TMBU'S TO INHIBIT ALL SIR-A FAULT MSG'S.	
30	EGIL-7	0/22 ^H 29 ^M	FUEL CELL #3 O ₂ flow meter is erratic, varied from 0 to off scale high.	

ANOMALY LIST

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	Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
31	PL-4	1/01'00 ^m	Lost AC 3 phase A power feed to OSTA pallet pump. This occurred \approx PET 0/02 ^h 35 ^m but was not confirmed until orbit 18.	
32	EECCM-8	01/02'30	Test was performed on FES PRI A+B controllers. PRI A controller would not control at proper temps. PRI B controller operated (with RAD controller in norm) until low heats encountered due to vehicle attitude and beta angles.	
33	IACC-2	01/03 ^h 40 ^m	Circuit breakers popped on RMS wrist/elbow cameras for pan/tilt. Crew reset breakers and they popped again.	
34	RMS-1	01/15 ^h 05 ^m	RMS shoulder yaw joint will not drive plus or minus in backup mode.	
35	PROP-5	01/05+45	LQMS XFEED VALVE B (Both Fuel & Ox) SUSPECT POWER TO VALVE LIMIT SWITCHES - EITHER SHORT OR OPEN RESISTOR. VALVE SHOULD REMAIN FUNCTIONAL - STILL UNDER ANALYSIS	OPEN

ANOMALY LIST

m	Anomaly No.	Time (GMT/PET)	Description/Impact/Resolution	Status
36	DPS-2	01/07+17	Crew reported I/O Error on CRT 1. They had inadvertently taken it to standby & can't get it back up (screen blank). At 01/09+33, DPS convinced that CRT 1 failed. Suspect internal pwr. supply vice R/F. Changeout being considered. Crew reported at 01/12+39 that CRT 4 had been swapped with CRT 1 & now have a working CRT 1.	CLOSE
37	PROP-6	01/8+30	OMS 3 & 4 DATA ANALYSIS INDICATES LOW OX QTY IS HUNG UP AT 43.2%	CLOSED

Statement of problem: Discoloration found in star tracker cavity on thermal blankets, after STS-2.

Discussion: Postflight inspection showed that portions of the white thermal blankets in the star tracker cavity had a yellowish-brown color.

Inspections of star tracker eyelid doors indicated that they were properly closed and sealed during reentry. Additionally, the star tracker cavity temperatures during entry did not exceed 85° F.

No evidence of light shade optical degradation was found. Analysis of samples of the discoloration indicates that it was caused by on-orbit deposition of hydrated silica, which is produced from outgassing of the red RTV material under the TPS system. The hydrated silica is deposited on all exposed spacecraft surfaces and entered the star tracker cavity through the open star tracker doors. The hydrated silica can not be removed by cleaning, but the deposition from STS-1 and 2 has not degraded star tracker performance.

Conclusions: The discoloration was due to hydrated silica outgassing from the red RTV and depositing on exposed surfaces.

Corrective action: Deposition of silica on star tracker protective windows and lightshades may require periodic removal and replacement of these items. Frequency to be assessed after STS-4.

APPROVED

1/15/82

A. Cohen

1/20/82

Date

Effect on subsequent missions: (See corrective action)

Personnel assigned: I. Savlietis/EH6; R. J. Ward/WA3

Resolution: CLOSED 01/18/82

Statement of problem: G22 star tracker alarms on -Z star tracker.

Discussion:The -Z Star Tracker (ST) detected several improperly formed incoming command words and issued transmission error bits resulting in the annunciation of three "G22 Star TRKR" alarms. During each inertial measurement unit (IMU)/Star Tracker alignment, several Manchester Not Valid (MNV) error bits were issued, and during 3 of the alignment periods, these error bits were seen by the Fault Detection System and annunciated. The Fault Detection System samples the Star Tracker register every 960 milliseconds while the star tracker samples the Manchester code error bits every 160 milliseconds. Several Bit Count Error (CBCE) and Parity Error (PE) bits also were seen in the -Z ST data while turned off. In addition, approximately 50 BCE, MNV and PE error bits were seen in the -Z data during the 17-minute interval from 318:00:05 to 318:00:22 G.m.t. while the -Z star tracker was turned off. Significantly, the only Y star tracker transmission errors were also seen during this period although the Y star tracker was operated during the entire 51 hours on orbit.

Transmission error bits are being generated in the GPC/MDM/ST/MDM/GPC PCM loop with the Z star tracker both on and off. Since the command word is repeated continuously, there is no impact to the star tracker performance.

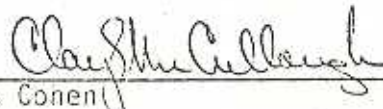
Conclusions: Transmission error bits are being generated in the PCM loop with the Z star tracker both on and off. These error bits are not a problem for star tracker operation.

Corrective action: Software has been changed to remove the "G22 Star TRKR" alarm. STS-3 data will be reviewed to determine if any further action is required.

APPROVED

by

A. Conen



1/27/82

Date

Effect on subsequent missions: None

Personnel assigned: M. Biggs/EH6; R. J. Ward/WA3

Resolution: CLOSED 01/27/82