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UNITED STATES GOVERNMENT

Memorandum

Eberal

TO : Flight Director, NCG 721

DATE: MAR 19 1969

FROM : Guidance Officer

SUBJECT: Postflight Report

1. Prelaunch - No problems.

2. Launch Phase.

a. Stripchart analysis of both Saturn IU and spacecraft CMC was performed during launch phase. The analysis was done on recommendation of the Data Priority as a CMC GO/NO-GO criteria prior to SPS-1. From C', it was known pre-mission that there would be errors in the CMC REFSMMAT and that the errors would be reflected in all traces. They would exhibit predictable trends and therefore could be accounted for. Limits were generated assuming the known CMC REFSMMAT errors.

b. During this phase the errors were building up, though not with the exact trends predicted. The values of ΔX and ΔV_T were growing almost linearly at a larger value than expected. ΔY and the Δ azimuth values were smaller. At approximately GET = 9:20, the IU vectors went static due to an onboard telemetry problem. Trends up to that point were reviewed. The CMC total velocity was lower than the IU at loss of data and again lower than IPR tracking at the GO/NO-GO's. The observed difference was approximately 10-12 fps. Since it was lower than the IU and IPR, it was declared "GO" for any Mode IV because any burn would result in a safe perigee. The CMC reflected the error in the crew-reported ha/hp = 103/89 versus tracking 107/99.

c. The next hour was spent chasing the error source. Since the lift-off was registered in the CMC approximately 1.1 secs later than predicted, it was initially suspect. A check of the RSO actual receipt of lift-off indicated only .4 secs difference and that source was eliminated. A second review of the trends established the X-accelerometer axis as suspect since there was an almost linear increase in the error trace until loss of the IU. A bias causes this sort of error. GNC perusal of PIPA bias was uncertain early due to Saturn venting while docked. A rev of observations did indicate a definite bias. Contact with preflight checkout personnel indicated that there was data showing a change of the X-bias pre-mission The real-time observed change equaled approximately 6_σ from a + to a - value.

d. Informally, we learned that KSC calibration indicated the bias trend. Apparently, there was not enough time to reverify the data to establish a confidence level which would warrant updating the CMC erasable memory to reflect the new bias. These things can happen, but to our knowledge no one in the MCC was apprised of the fact. This includes GNC and AGC Support.

AGC Support is responsible for the CMC erasable memory prior to lift-off. We feel like there was some breakdown in communication between the KSC checkout personnel and the MCC Operations people. By nature of the mass of constants which can be/are changed pre-mission, the system has always functioned whereby appropriate Operations people are informed of non-nominal performance which may be expected.

e. The trajectory orbital element checks were being made at the appropriate times to verify whether the PGNS could be considered "GO" prior to SPS-1. This check was considered unnecessary after all involved were certain of the X-accelerometer bias since, essentially, all the error was in the X-axis. As general interest, had the error been indeterminate, the CMC vector reflected sufficient errors to border on the "NO-GO" limits.

f. The CMC torquing angles did confirm normal azimuth misalignment errors and the REFSMMAT bias. They were:

(1) X + .116 degrees at the first P52 realignment

(2) Y - .032

(3) Z - .108

g. A CMC state vector was uplinked at the end of the first States pass to alleviate the vector problem. The PIPA bias was not updated prior to SPS-1 since it would have little effect on the burn and GNC would have longer to get a better value prior to updating. The CMC was declared "GO" for SPS-1.

3. SPS-1.

a. During the first sim of SPS-1, a time tag of 4+00 GET was used for state vector and the REFSMMAT computed by the CMC differed from the RTCC computed REFSMMAT in the third decimal place. This was determined to be due to differences between the RTCC vector and the CMC vector which is used to define the LVLH system at SPS ignition.

b. To minimize this, the vector time tag should be as close to Tig as possible without being time tagged more than one rev in the future from the time the vector is uplinked. Since this vector was to be uplinked at approximately 3+10, a time tag was chosen of 4+40.

c. The resultant state vector uplinked at 3+10 was in error because it included both the ejection maneuver (.7 fps) and the evasive maneuver (.4 fps). This was discovered right after the uplink was completed and verified. A vector compare was made at SPS-1 Tig which gave a downrange error of approximately 2 miles. This would result in a slight execution error in pitch and would be considered inconsequential in terms of effect. The Flight Director was notified of this and no update was recommended.

d. To keep this from happening the procedure was redefined to keep the FDO and GDO tagged up. The GDO generated the state vector update

based on a GO from FDO when the ephemeris update was complete in the RTCC. GDO gave FDO the GETSV and FDO generated a NAV check. This makes both GDO and FDO responsible for verifying that no maneuvers are in the MPT (that should not be there) between the time the update is generated and the time tag on the vector.

e. At acquisition on the States pass at $\approx$ 4+33, it was noted that the CMC was still in P47 with average G running (P47 was selected at CRO to monitor EJECTION). Another vector compare was made at SPS-1 Tig and the original 2 n.m. downrange error had grown to a much larger error due to excessive average G time with the bad X-accelerometer PIPA bias data being incorporated. At this time, a state vector update over ACN was recommended to Flight. The vector was uplinked to the CMC at ACN; however, this vector was not used by the CMC in the calculation of its REFSMMAT for SPS-1 because the crew had already completed P30 and P40 to the point where the preferred orientation is computed and they were in P52 at acquisition of ACN. The vector was uplinked at ACN after exiting P52 but the crew did not recycle through P30 and P40 and recompute a new preferred REFSMMAT, therefore the CMC definition of LVLH was based on the old vector. Also pactoff and yactoff were loaded on the launch pad with δP of -1.37 degrees and δY of +1.34 degrees which was for an undocked SPS 2-1 reentry. This was due to a Flight Plan oversight which placed the DAP data loading after P30/40 instead of before them. The SPS-1 pad had a δP of +1.0 degrees and a δY of -0.2 degrees for a docked maneuver. These values were not loaded into the CMC prior to P30/40 to be used in the calculation of its preferred REFSMMAT. The error in δP was 2.37 degrees plus the state vector error resulted in an error in the pitch axis of over 3 degrees. The error in δY was 1.14 degrees which resulted in yaw axis error of 1.14 degrees. At this point, the crew was informed of the error in pactoff and yactoff and the pad values were loaded. The correct CMC noun 18 display of final attitudes was now not R=0, P=0, Y=0 but R=0, P=357.7, Y=1.6. Table 1 reflects maneuver execution data. The Vg's gained during the burn were integrated by the CMC onto the vector that was uplinked at ACN, so the vector in the CMC after the burn was good. SPS-1 was executed with a pitch pointing error equivalent to the state vector downrange error--the whole reason for the vector update over ACN.

f. To avoid this in the future, any time the crew has completed P30 and a state vector is uplinked, they should be told to go through P30 and P40 again. Recycling of P52 is only necessary if the desired orientation R,P,Y gimbal angles are to equal zero.

4. SPS-2, SPS-3, and SPS-4.

The crew executed these burns using the CMC mass and stored engine trim angles. Dave Scott and GDO agreed to use CMC track mass and DAP stored engine trims as long as there had been no large amount of RCS usage between burns and no configuration change had taken place since the last burn and that the ΔT_B of the last burn was long enough for active steering by the guidance system. Ground calculations of SPS-3 and 4 used the DAP stored values of pitch trim and yaw trim and the GNC's best estimate of weight. Ground and CMC calculations of preferred REFSMMATS were in very good agreement. For residuals see table 1.

5. Docked DPS.

a. The crew read the docking angle which was +2.10 degrees. The bias was +.26 and a docking angle of +2.36 was input to the RTCC. All previous maneuvers were computed using a docking angle of +1.01 degrees which assumed a perfect alignment, because crew was unable to read the docking angle on day one.

b. Two sets of gyro torquing angles were computed by the ground for the docked alignment and they were:

FIRST	SECOND
Outer = +0.910 degrees	Outer = -.040 degrees
Inner = -0.150 degrees	Inner = +.180 degrees
Middle = +1.210 degrees	Middle = -.160 degrees

Based on residuals, the DPS maneuver was almost perfect. Comparisons between CMC, LGC, and AGS follow:

LGC	CMC
Accumulated velocity in stable member coordinates	Accumulated velocity in stable member coordinates
Vgx = +1739.1	Vgx = +1739.2
Vgy = - .1	Vgy = - 1.1
Vgy = - .1	Vgz = - 0.5
Control Axis Residuals	Control Axis Residuals
Vx = +4.2	Vx = -4.7
Vy = + .1	Vy = +3.8
Vz = + .2	Vz = -1.3

AGS RESIDUALS

Vx (500) = +3 fps
Vy (501) = -5 fps
Vz (502) = -0 fps

TOTAL AGS RESIDUAL = 3 fps

The determination of the docking ring location (bias) and reading on the ring for a perfect docking should be made a required measurement on all future vehicles.

6. SPS-5.

a. SPS-5 was executed with no problems, however, the cross axis residual was +11.1 fps. MIT had run simulations of SPS-4 and SPS-5 and

had predicted cross axis residuals of 5 to 10 fps for burns with burn times from 20 to 45 secs. However, SPS-5 burn time was 43 secs and lower cross axis residuals were expected. These errors are a direct result of the low gain in the docked autopilot. A note received from MIT after SPS-5 said that MIT believes that the performance of SPS-5 does not indicate any non-nominal behavior. Since SPS-4 burn time was 28.3 secs and its residuals were only 3.5 fps in the cross axis, it would seem that SPS-5 would be smaller than SPS-4.

b. The DAP has been corrected, MAYBE in Colossus II so this problem should not be seen again. For residuals of SPS-5 see table 1.

7. Rendezvous.

a. Uplinked rendezvous REFSMMAT to CSM after FDO had plan in MPT.

b. Computed LM gyro torquing angles for second docked alignment which are as follows:

(1) Outer = -0.370

(2) Inner = -0.790

(3) Middle = -0.310

c. LM torquing angles during the P52 performed after SEP maneuver were:

(1) R = -0.098

(2) P = -0.076

(3) Y = -0.111

d. CMC torquing angles during P52 performed after SEP maneuver were:

(1) R = +0.117

(2) P = +0.035

(3) Y = -0.109

8. Phasing Maneuver.

a. Phasing maneuver executed under AGS control looked smooth.

(1) Tig = 93+47+34.00

(2) Vx = +0.9

(3) Y = +0.0

(4) Z = -90.7

b. LGC residuals after trim were:

(1) Vx = +0.1

(2) Vy = -0.1

(3) Vz = 0.0

c. AGS residuals after trim were:

(1) Vx (500) = 0

(2) Vy (501) = 0

(3) Vz (502) = -1

9. Insertion - Nominal.

10. CSI - Telemetry taken over BDA and CYI showed that the crew had initialized P32 with a CSI Time = 96+17+00, APSIS = 1, TPI Time = 98+01+00 and they had a valid solution which looked good. The CSI pad was passed over CYI with a CSI Time = 96+16+03.00 and a TPI time of 97+56+23.00. These were input to P32. Then the crew asked what apsis they should use. Since radar marks had been taken, GDO thought that with these new numbers input to P32 that the LGC thought an apsis was occurring immediately after CSI which would require an input of APSIS = 2. The back room also said use an APSIS = 2 which was passed to the crew. However, 2 or 3 minutes later RNDZ questioned this and said that their data showed that an APSIS = 1 gave the correct solution. Also at this time, AGC/MIT recommended going back to APSIS = 1. This was passed to Flight and CapCom, however, CYI had LOS and the information probably did not reach the crew. Since similar situations had arisen during the crew's training at the Cape, the crew knew what to do to correct the problem, but the big concern was that the Final Flag had been set in P32 and this required a recycle and proceeding through P32 twice to get the Final Flag set again and to get the final solution displayed and stored for P4X and P33 programs. Since it was only a few minutes to CSI Tig, there might not have been enough time for the crew to do this.

11. CDH - The ground received the LGC biased CDH time of 96+58+14 and computed CDH at the same time. Comparisons are as follows:

LGC CDH	GND CDH
Vx = -39.2	Vx = -38.2
Vy = +00.1	Vy = -00.9
Vz = -13.7	Vz = -15.1

12. TPI - CMC, LGC, and GND solution comparisons are:

	LGC	CMC	GND
Tign	97+57+41.03	97+58+19.12	97+57+45.00

	LGC	CMC	GND
F	21.7	F21.2	F22.3
R	0.8	L .2	L00.0
U	.2	U 1.1	U00.3

13. APS Burn to Depletion.

a. The APS depletion pad was passed to the crew over GWM and everything went as planned until the CMC started to maneuver to evasion attitude and went into gimbal lock. The crew had loaded the GND supplied attitude into R60 for an auto maneuver to burn attitude. The gimbal lock avoidance routine has been removed from Colossus and it is the crew's responsibility to maneuver around gimbal lock. It appeared that a proceed was entered to V06 N18 display of desired gimbal angles and the CMC went through gimbal lock.

b. However, the crew informed us that they were a safe distance away and the APS burn was completed as scheduled by ground control. It was recommended to power down the IMU rather than do a P51 since it was scheduled to be powered down shortly at any rate.

14. SPS-6 - First attempt at GET 121+48+57.60 DAP was configured with quads B,D selected, and quads C and D failed (R_2 = 01100). Autopilot will not give +X translation in this configuration. AGC picked up the error in the DAP load and reported same to GDO and GNC. GNC notified Flight. SPS-6 was delayed to GET 123+25+05.90 and was executed with no problems. For residuals see table 1.

15. SPS-7 was nominal; for residuals see table 1.

16. SPS-8 - The state vector time tagged 237+25+00, target load and REFSMMAT for SPS-8, were uplinked at approximately 235+50. The crew aligned to the desired REFSMMAT at 236+50. After the crew had completed P30 and P40, the CMC VG IMU's did not agree with the grounds at 238+35. It was determined to be the difference between the ground and CMC state vector, and a state vector update was recommended to Flight. At this time, the ground was showing a downrange error of 2 n.m. in the CMC state vector. The state vector was uplinked over Redstone at 239. GETSV = 240+30+00. The crew was told to go through P30 and P40 again. The CMC VG IMU's agreed perfectly with the ground after completion of P30 and P40. The maneuver was executed on time. For residuals see table 1. Although the recommendation for the state vector update may have been questioned by some, no one showed displeasure with the real time TV coverage.

17. Command Problems.

a. It was requested to have the command handover plan for the States pass starting at 48+00 to be completed by 49+40 so that we could load the proper sites with state vectors for both vehicles and the LM DPS REFSMMAT. The Plans Controller told us that they would hand over from GYM to MIL and that TEX would be passive. Therefore, the CSM state vector was transferred to GYM/MIL and the LM state vectors and REFSMMAT were transferred to MIL/BDA/VAN/CYI. But they did in fact hand over to TEX

and we had to delay commanding to the LM until TEX handed over to MIL. Also the group display channel 61 also said that TEX was passive. We had a similar problem during every sim. It is not required to have the handover plan this far in the future on a rev by rev basis, but only on identifiable problem passes such as the above.

b. The only other command problems experienced were expected, when we were commanding with ratty TM on very low elevation passes at the end of each day when the S/C is going off the range.

18. Orbit Rate Torquing.

a. The crew checklist did not list the constraints that went with the table of octal values in steps 6, 7, and 8. The constraint is that the table is valid for a posigrade alignment. At 125+20 over HAW where the crew set up to do landmark tracking using the YAW/ROLL, their alignment was retrograde which was preferred for SPS-6. When the crew loaded the values from the table, the S/C was torqued off in the wrong direction. The value of W should have been complimented to cause the S/C to torque in the correct direction.

b. At 142+00, the values of V, W, X, Y, and Z were passed up to the crew. These assumed a CDUX angle of 0 degrees, however, FAO had requested FDO to compute attitude for a CDUX angle of 180°. This resulted in W, V, and Y having to be complimented. This was caught by Rus Larson, MIT, when the crew went to attitude. The compliment of W, V, and Y was read up to the crew.

c. Had FAO, GNC and GDO been given the tables earlier, and had been briefed as to what they were for and how to use them, most of the confusion could have been avoided.

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SPS BURNS

		TARGET		ACTUAL		
		IMU COORD	LVLH	IMU COORD	RESIDUALS	II
SPS #1	V_x	+ 36.8	+ 36.8	+ 34.1	+ 1.6	
	V_y	+ 0.5	+ 0.0	+ 0.4	+ 0.5	
	V_z	+ 0.8	+ 0.0	+ 1.9	- 0.2	
SPS #2	V_x	+ 850.4	+ 99.3	+850.6	-0.1	
	V_y	+ 10.9	- 844.6	10.3	+ 0.7	
	V_z	+ 17.2	+ 17.6	16.9	+ 0.3	
SPS #3	V_x	+2570.1	+ 15.1	+2567.5	+2.6	
	V_y	+ 35.0	- 2570.7	+ 37.1	- 2.1	
	V_z	+ 43.2	- 0.2	+ 45.5	-2.5	
SPS #4	V_x	+ 300.9	- 1.2	+300.5	+ 0.3	
	V_y	+ 1.4	-300.9	- 2.9	+ 3.5	
	V_z	+ 3.4	+ 0.0	+ 0.7	+ 3.2	
SPS #5	V_x	+ 575.3	- 210.9	+ 575.9	+ 1.9	
	V_x	+ 1.4	- 377.5	- 10.4	+ 11.1	
	V_z	+ 10.4	+379.6	+ 8.4	+ 3.4	
SPS #6	V_x	+ 38.8	- 38.8	+ 37.6	+ 1.1	
	V_y	- 0.3	0.0	- 0.1	- 0.3	
	V_z	+ 1.9	0.0	+ 1.9	- 0.4	
SPS #7	V_x	+ 652.4	+ 227.0	+ 653.5	- 1.3	
	V_y	- 1.7	- 590.0	- 2.7	+ 1.0	
	V_z	+ 34.6	+ 165.0	+ 35.1	- 0.2	
SPS #8	V_x	-324.6	- 196.9	- 324.7	+ 0.1	
	V_y	- 0.1	+ 0.0	+ 0.3	+ 0.2	
	V_z	+ 15.7	+ 250.5	+ 15.6	+ 0.1	

TABLE 1

CMC STATE VECTOR UPDATES

CSM STATE VECTORS

LOAD #	GET UPK	SITE	GET SU		PURPOSE
0003	1:45:00	BDA	2 :30:00	V66	TD&E
0004	3:15:00	BDA	4:39:00	U66	EJECTION
0006	5:05:00	ACN	5:58:00	U66	SPS #1
0008	20:45:00	UAN	22:11:00	V66	SPS #2
0010	23:55:00	BDA	25:16:00	V66	SPS #3
0012	28:50:00	ACN	30:10:00	U66	POWER DOWN
0013	40:55:00	GWM	42:30:00	U66	POWER UP
0014	48:00:00	GYM	49:30:00	U66	DOCKED DPS
0016	52:52:00	TEX	54:20:00	V66	SPS# 5
0017	55:50:00	HAW	57:00:00	U66	POWER DOWN
0021	76:35:00	GDS	77:30:00		POWER DOWN
0022	89:05:00	MER	90:30:00	U66	RENDEZ
0023	92:45:00	ANG	93:00:00	U66	SEP
0024	103:05:00	GWM	104:00:00		POWER DOWN
0026	119:30:00	BDA	121:00:00	U66	POWER UP
0028	122:30:00	TEX	123:24:00	U66	SPS #6
0029	126:40:00	GWM	128:00:00		POWER DOWN
0031	141:35:00	MIL	142:46:44	U66	LANDMARK TRACKING
0033	148:50:00	GWM	150:15:00	U66	POWER DOWN
0035	168:07:00	GYM	169:37:00	U66	SPS #7
0037	174:10:00	RED	175:25:00	U66	POWER DOWN
0039	187:33:00	MIL	189:00:00		POWER UP & SOGS
0042	198:20:00	RED	200:00:00		POWER DOWN
0044	211:45:00	TEX	213:10:00		POWER UP
0046	217:25:00	CRO	218:30:00		POWER DOWN
0049	235:55:00	TEX	237:25:00		POWER UP & RETRO
0050	237:25:00	GDS	238:54:00		RETRO

LGC STATE VECTOR UPDATES.

	LOAD #	GET UPLINK	SITE	GETSU	PURPOSE
LM	2001	48:10:00	MIL	49:30:00	V66 DOCKED DPS
LM	2002	91:20:00	CYI	92:30:00	V66 RENDEZ.

CSM REFSMMAT LOADS

LOAD #	GET UPK	SITE	REFS & PURPOSE
1202	41:00:00	GWM	MED 005 DOCKED DPS
1206	89:00:00	MER	LCU 003 RENDEZ
1213	192:25:00	BDA	DMT 006 HIGH GAIN ANTENNA TEST
1217	235:50:00	MIL	DOD 010 RETRO FIRE / REENTRY

LM REFSMMAT LOADS

2301	48:10:00	BDA	DMT 002 DOCKED DPS
2302	89:45:00	CYI	CUR 002 RENDEZ

EXTERNAL ΔV LOADS

LOAD #	GET LIFTOFF	SITE	[redacted] PURPOSE
1001	4:50:00	ANG	SPS #1
1002	20:40:00	ANG	SPS #2
1003	23:50:00	BDA	SPS #3
1004	26:50:00	TEX	SPS #4
1005	52:50:00	TEX	SPS #5
1006	119:30:00	BDA	SPS #6
1007	122:30:00	MIL	SPS #6 — 1 REV
1008	168:00:00	GYM	SPS #7
1345	235:54:00	TEX	RETROFIRE