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OCT 3 1969

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OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : FS55/Head, Apollo Guidance Program Section

DATE: SEP 19 1969

In reply refer to:
69-FS55-31

FROM : FS55/Head, Program Support Group

SUBJECT: Apollo Mission G Post-flight Summary - AGC support (console 37, Flight Dynamics SSR)

1. Prelaunch

a. For the CSM, prelaunch activities were nominal. Due to high CMC clock drift rate (gain .0086 sec/hr), the clock at our request was biased slow by four centiseconds at 9:17 CDT on July 14, 1969. E-loading was monitored and verified (had some data problems - CP was recycled during loading somehow). E-memory dump was initiated, processed, and verified. There were three late changes to the E-load (done by hand).

b. For the LM, prelaunch activities for us consisted of LGC E-loading during the CDDT and one week later reloading after flight ropes were changed. We successfully monitored the first loading, but the second came earlier than scheduled and the Test Conductor did not want to wait for Houston to come up. We, therefore (with Houston Flight Director advised), did not monitor E-loading and did not receive an E-memory dump. Fortunately, the necessary hand-load changes were made correctly via telephone conversations between us and the KSC personnel, as verified by the E-memory dump obtained from the LM in-flight the morning of descent.

2. Launch through TLI and TD&E

a. The CMC detected liftoff at CMC time of 37:32:00.78 (equivalent to July 16, 13:32:00.78 GMT). There were frequent CMC data dropouts and occasionally bad data during launch. At insertion, the CMC gave Hp 101.4 by Ha 103.6, the CSM state vector was transferred to LM slots (V66E) and the Saturn DAP was turned on. The first P52 gave a Z gyro correction of $+.152^{\circ}$ (see P52 log enclosed for complete history of P52's).

b. At TLI cutoff, the CMC registered an inertial velocity of 35,579 fps (versus nominal of 35,575). LM ejection was performed with CMC in P47 and the trunnion bias cell was zeroed via uplink in case the crew did not do a trunnion calibration prior to subsequent P23 activities. The SPS evasive maneuver was performed (data enclosed) nominally except that (as was to be true for many CSM maneuvers) the CMC was not allowed to trim attitude prior to the burn. The MTVC test done prior to each burn required SCS control. Upon returning to CMC control, the CMC will hold attitude deadband around the attitude existing at the time of return to CMC control (unless attitude is trimmed - another PRO on F5018). This is no problem for long burns but it did cost about 1° in yaw on this burn, although it must have been a compensating error as residuals came out almost perfect.

3. Translunar

a. There was quite a bit of trouble with the Day 1 P23 exercises. It was, however, mostly straightened out by the time Day 2 sightings occurred - and they seemed quite successful. Two papers written in real time are enclosed - one titled "P23 Comments" giving a summary of all the problems and the other "P23 Recommendations" which is what was almost literally read up to the crew prior to Day 2 P23 activities.

b. At GET 12:30, it was noted that the crew had a N65 (CMC time) monitor going, evidently with no plans to turn it off overnight. We notified the FAO (after conversing with MIT/IL) and requested it be terminated via V34E sooner or later because of the DSKY relay lifetime problems. Guido was also informed and they all talked it over. It got to the crew and they responded with a V46E ("overkill" - this blanks the DSKY alright, but it also restarts the DAP) which kills all CMC PTC control. Fortunately, all jets were disabled, but we did manage to get the crew advised of what they had done and a reminder (therefore) to take care in enabling jets (the next morning).

c. We saw an interesting phenomenon on the CMC clock (19:40) in that the clock was jumping back and forth by a centisecond which means that the TLM was sampling the clock right at the time it was ticking up. See enclosure for complete CMC clock history - "Apollo 11 - CMC Clock."

d. MCC2 went perfectly - see enclosure for burn data.

e. Via a telephone conference call between (approximately GET 32:00) G&CD, Grumman, MIT/IL, etc., and us, the LGC LR position E-load parameters were finally decided upon. The decision was to ignore the measured offset data and put in the nominal numbers (hence, perhaps not best available, but certainly trustworthy and better than what was then in the LGC). Mr. E. F. Kranz was most cooperative and understanding in honoring our request to make what could have been this hard-to-defend change. The request is enclosed.

f. Based on the new mission rule, CMC IMU compensation parameters (PBIASY, PBIASZ, NBDX, NBDY, NBDZ) were updated to the most recent measurements at GET 31:20. This must be taken into account if attempts to compute IMU drift between the P52 alignments at 24:16 and 52:59 are made! (See CMC P52 summary sheet - enclosed).

g. There were a few PTC initiation problems starting at about 34:40. Enclosed is a writeup by Mr. P. Weissman titled "PTC FLAP." Of note is the fact that the PTC procedure as written in the checklist assumes a blank DSKY. This assumption failed both in this case (the crew loaded N18 by mistake) and in a later case (they loaded N20, the actual CDU cells, by mistake).

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h. At about 53:00 during a phone conversation with Mr. J. Norton (TRW), he pointed out that command load starting addresses in LUMINARY section 2 had not been updated to reflect the latest program revision. Just as a check, we asked the Guido's to generate a sample of each load both CMC and LGC. The preferred REFSMMAT starting address (LGC) was wrong. The only other GSOP error was the XΔV load which the RTCC had gotten corrected (as it is used all the time in simulations). The CMC loads were all correct.

4. LOI Day

a. During the uplinking of LOI loads ($\approx$73:42) a long-lived frustrating mystery was solved when a bug in P00 (if you can believe that) was discovered (both LGC and CMC have it). The problem is that P00 integration checking (which occurs each 10 minutes and decides whether or not to integrate based on the CSM vector being more than 4 timesteps old) examines which program is currently running. Only if the program is 00 does it do the normal P00 logic, otherwise it integrates the CSM vector to current time (and subsequently the LM vector to the same time). As it turns out, the program can be 27 (uplink) and will cause this exact problem. For a burn, the usual procedure is to uplink a vector tagged in the future near TIG. P00 should not ever integrate it backwards. Infrequently we had seen the vector suddenly back near current time long after we had uplinked it. For LOI, the same thing happened, only this time we actually saw the integration occur and it happened while uplinking (target load, I believe - after the vector uplinks at any rate), and Mr. Norton took a quick look and found the program test in P00. We put all the pieces together and decided that the main reason we had seen this so infrequently in the past was that the crew (in all previous flights, not this one) purposefully selected P00 (V37E00E) just prior to each uplink even if P00 was already running. This gave 10 minutes before the next P00 test would come along, usually more than enough time to complete all uplinking. The bug is in the CMC and LGC (we saw it in both during this flight) and I believe has been fixed in the Apollo 12 LUMINARY program though not yet in the CMC (Apollo 12 CMC program had been already released).

b. LOI_1 and LOI_2 were both good burns - see enclosed burn sheets.

c. At AOS, GET 82:34, the CMC was in P22. He took five marks and was out by 82:52. The loaded and computed N89 were (see also P22 enclosure):

	Loaded	Computed
LAT	2.000	2.009
LONG	65.500	65.188
ALT	0.00	-1.766

And RLS was not updated (per plan). The second CMC clock update was sent following this P22 at 83:20 (see enclosure).

d. After a state vector uplink at 83:27, it was noted that the least significant bit of both Y and Z were off by one though there were no non-compares (Sykes AGC, Renick Guido). RTC reported that his hardcopy of the load matched the uplink. After some time, the load was accepted (V33E) as is; and I assume the problem, by now, has been solved (e.g., possibly the load was regenerated after we took hardcopies of the original).

5. LM Activation to Landing

a. At 96:40, it was noted (Mr. J. W. Jurgensen) that the CMC optics were on, in zero mode, yet CDUT read 11.25. This required cycling of the optics zero switch, and the CSM was so told via the LM, and in fact this was properly done prior to the CSM P52 option 1 at 96:55.

b. The LM crew set their LGC clock to the CMC clock at 97:00. Their accuracy was .03 seconds. Computations and data:

	LGC	CMC
ΔT	1.332	1.285 seconds
Air-GRND Delay	1.295	1.281 seconds
True ΔT ⟶	+.037	+.004 seconds

Hence, the LGC was lagging the CMC by +.033 seconds (+.037 - .004) and an LGC time increment uplink of +.03 was sent at about 98:58.

c. TEPHEM was read out of the CMC and loaded into the LGC at about 97:05. The value matched our computed prediction.

d. The initial LM IMU coarse aligning was done based on CSM attitude of CDUX 112.02, CDUY 207.41, CDUZ 2.11 and a docking angle of 2.05. The resultant coarse align angles of CDUX 190.03, CDUY 27.41, and CDUZ of 357.89 were input at about 97:10 followed by a CDU zero.

e. Torquing of the LM IMU was done based on CDU angles of:

LM	189.95	28.52	358.63
CSM	111.54	207.92	2.30

with resultant ground computed torque angles of:

-00.060	+00.620	+01.080

with torquing done at 97:26.

f. CSM P22 at AOS (98:22 - see enclosure).

g. It should be noted that the P00 integration anomaly pointed out a procedural problem in initial LM state vector uplinking. Both state vector timetags are set to POSMAX via the E-load to prevent P00 integration. Unfortunately, no matter which vector is uplinked first, if a P00 integration 10-minute check occurs between the two uplinks, then the computer will lock up integrating between POSMAX time and current time (one direction or the other). The case that actually occurred (at 98:57) was similar in that while uplinking the LM vector, the P00 anomaly caught the CSM vector and the LGC locked up in integrating it back to current time. A V96E was uplinked resulting in P00 integration inhibit and incorporation of the LM vector (since the V96 was done after the final V33 on the LM vector). A V66E followed by normal selection of P00 (V37E00E) was subsequently uplinked to complete state vector initialization. A V96 should be procedural in the future.

h. Torque angles were computed for a drift check based on CDU angles of:

LM	303.74	200.78	00.53
CSM	358.64	20.73	359.54

with resultant torque angles of:

+00.330	+00.050	+00.050

which were <u>not</u> read up to or torqued by the crew.

i. A P52 option 3 (LM) was completed (torqued) at 101:20 GET using detent 2 with stars 25 and 33 with N05 of +.03° and torque angles of: -0.292, +0.289, -0.094.

j. During descent, the LGC experienced five software restarts of the executive overflow type. They were:

Alarm 1202 in P63 at PDI+316 seconds
Alarm 1202 in P63 at PDI+356 seconds
Alarm 1201 in P64 at PDI+552 seconds
Alarm 1202 in P64 at PDI+578 seconds
Alarm 1202 in P64 at PDI+594 seconds

The alarms were due to a rendezvous radar resolver excitation problem caused by having the RR on but not in LGC mode (per checklist). The exact cause will not be discussed here but rather, reference should be made to MIT/IL memorandum AG#370-69 from Mr. G. Cherry to Mr. C. Kraft entitled "Exegesis of the 1201 and 1202 Alarms Which Occurred During the Mission G Landing," dated August 4, 1969. A few items of historical note should, however, be pointed out. One of the later G mission descent simulations resulted in an abort called by the Guidance Officer as a result of continuous 1210 alarms (software restarts) which locked up the LGC DSKY and which we could not explain as they were "impossible" (a portion of the LGC hardware was failed in the simulation, it turned out). This simulation justifiably gave some concern to the Flight Director (Mr. Kranz) over the preparedness of Mission Control to react to random program alarms during descent. More important to us, it brought again to the spotlight the question of AGC status under conditions of continuous software restarts (i.e., a restart loop). As a result, the Flight Director requested a descent program alarm review which we supported in person and with a rather lengthy complete writeup of all LGC alarms (it is interesting to note that no such writeup existed prior to that time). The meeting physically resulted in a GO/NO-GO for descent program alarm sheet which we prepared and is enclosed with our descent checklist. The most important results of the meeting, however, were:

(1) Education of MOCR personnel into the alarm structure of the LGC which aided to no end in reducing the critical time-consuming explaining which we had previously been forced to do in order for program alarms to be acted upon.

(2) Virtually no change to the GO/NO-GO philosophy that we have held on specific program alarms, except that we were allowed to explain it [i.e., (1) above].

(3) Most important of all, an "executive" decision on the one category of alarms that we had previously been "playing by ear"; to wit - repeating software restarts during the premanual takeover capability phase of descent would not, in themselves, be cause for abort.

Hence, the real time occurrence of the 1201 and 1202 alarms resulted in a "GO" callout from us (they weren't even repeating or locking up the LGC). Since the first two alarms occurred while a monitor verb was running (V16N68), our initial thoughts were that the computer was simply closer to 100% duty cycle than anticipated. The monitor knocked it over the top and the resulting alarm terminated the monitor, thus yielding a successful recovery. We were, therefore, quite worried that the crew might initiate a monitor during the P63/64 transition which would cause an alarm that would invoke a program note concerning no restart protection for LR position transition for which the crew carried a rather complex workaround. This, fortunately, did not occur; however, in P64 with no astronaut initiated DSKY activity, the DSKY went blank for a considerable length of time and the one 1201 alarm occurred (again: recovery with no repeating so we called "GO, same type") and it was, therefore, clear that something was seriously wrong with the computer at that point. However, in spite of our hypertension, the computer issued no more 1201's and only two more single occurrences of 1202. It should be noted that Mr. G. Silver of MIT/IL was the first to inform us of the probable hardware problem which resulted in our requesting a switch position change just prior to ascent (i.e., RR off but in LGC mode).

6. Lunar Surface

a. The initial P57 in the LM (≈103:00) showed the LM to be tilted off the local gravity vector by 4.53°. The CDU's at touchdown were: 13.00, 4.37, 0.33, which confirmed the tilt and showed a vehicle yaw to the south of 13 degrees. SURFFLAG was set in the CMC at 102:49:45, and a P22 was performed starting at AOS 104:15 (see enclosure).

b. P57's in the LGC were:

(1) 103:10:38 - Option 3, Tech. 1

NO4 = 4.53°, repeat NO4 = 0.01°
Star angle was 0.15° with torque angles of
+0.005, -0.105, -0.225 with <u>no torquing</u>

(2) 103:48:12 - Option 3, Tech. 2

Star 12 detent 6, star 3 detent 4
Star angle +0.09°, with torque angles of
-0.167, +0.186, +0.014; torqued at above time.
See RLS enclosure for resulting landing site computation.

(3) 104:16:19 - Option 4, Tech. 3

N34 = 104:39:37.00, NO4 = 0.00°
Star 12 detent 6, star angle +0.08° with
torque angles +0.228, -0.025, -0.284;
torqued at above time.

(4) 122:17:15 - Option 3, Tech. 3

NO4 = 0.10°, recycle NO4 = 0.01°,
Star 13 detent 4, star angle of +0.07°
with torque angles of
-0.699, +0.696, -0.628 torqued at
above time.

(5) 123:44:50 - Option 4, Tech. 3

N34 = 124:22:00.00, NO4 = +0.01°,
recycle NO4 = +0.01°, star 13 detent 4,
star angle +0.11°, with torque angles of
+0.089, +0.067, -0.041, torqued at above time.

c. The CSM performed a P22 at 108:33 with no marks, 110:38 with no marks, and 112:24 with no marks. Another P22 was done at 122:07 (see enclosure).

d. At 112:14, a state vector was uplinked to the CMC writing over a preferred REFSMMAT that had not been used yet. It, therefore, had to be re-uplinked (CMC).

e. The LM did a P22 at 122:17 in the no-update mode with lock on at about 122:20:46, LOS 122:22:05. We informed the Guidos that no subsequent lock on would be possible (RR out of limits) but a recycle was tried anyway with a resultant 526 alarm (CSM too far). We understand that an RTCC anomaly plus misunderstanding of LGC P22 operations prevented real time processing of the P22 data.

7. Lunar Launch through TEI

a. Ignition occurred at 124:22:00.00 with cutoff at 124:29:14.88. See enclosed ascent checklist for further details.

b. A P52 option 3 (LM) was completed (torqued) at 124:51:30 using stars 25 and 13 with a N05 of +0.000 and torque angles of: -0.006, +0.064, +0.137.

c. The rendezvous was nominal except that:

(1) The CSM optics were turned off but left in CMC mode (during backup burn preps) resulting in trunnion high drift to the plus stops. Subsequent auto-optics recognized the trunnion as at a negative angle, thus causing plus driving into the stops. Optics zero corrected the situation and a COLOSSUS anomaly report has been written on the ambiguous trunnion scaling.

(2) The LM IMU was allowed to drift into gimbal lock during docking. The IMU was set inertial at 0,0,0 CDU's using nominal recovery procedures but ignoring proper inertial alignment. By grabbing simultaneous CDU readings from the docked CSM and LM IMU's, a REFSMMAT for the LM was generated but never put in the LGC. Also, the recovery procedure called for a V37 after a V40N20 but there should have been a 15 or 20-second wait. As a result, some improper moding flagbits were set in the LGC but we did not call them out since the IMU was aligned anyway. They were corrected via uplink after jettison.

d. The LM evasive maneuver was performed at 130:30:00.00 GET. See enclosed burn checklist.

e. There was much uplinking to the LGC; some to analyze the IMU degradation (primary coolant had been turned off), other just experimentation. At 131:52:10, the IMU TEMP warning came on. RR self test was kept running quite often and gave nominal results (after the CSM transponder was turned off) with remoding occurring from time to time as the RR drifted into the software shaft and trunnion stops. PIPA temperature went off-scale high at 132:46. An unexpected event, CDU fail, occurred at 132:54 (PIPA's normally go first) with resultant freezing of LGC CDU counters (LM was in AGS control). At AOS (133:46), the CDU fail had been joined by a PIPA fail. The failures seemed to be cycling since uplinked error resets would only momentarily clear the FAILREG's. Attempts were made to torque the IMU with no success (with a 10° input, only slight resolver movement resulted with, of course, no CDU counts). At AOS 135:44, an IMU FAIL was also present and also seemed to be cycling on and off. If such cycling behavior is normal on such failures, then a workaround should be added to the crew checklist to prevent the program alarm light from being continuously on if the computer is to be subsequently used for anything. A hardware restart was forced (uplinked V69) at 136:01:51, with no apparent effects other than the restart (the LGC too was without coolant). The LGC finally apparently died (LOS) at

136:48:41.50 (last telemetry sample showed just the one restart), giving as a single data point an LGC lifetime of over seven hours without coolant.

f. TEI occurred at 135:23:41.56 - see enclosed burn checklist.

8. Transearth through Splash

a. We had one of our usual PTC initiation problems at 150:40. A N20 (ACDU) monitor was going during PTC initiation causing the crew (in following their checklist) to load the CDU's instead of one set of the PTC erasables. This caused the DAP rate estimator to compute very high rates and jets were fired to counteract this artificial rate, thus causing a real rate. CMC control was removed before the rate got too high, although it would have most likely reversed and damped out before too long, of its own accord.

b. A ΔT uplink of -0.08 second was sent at 160:10.

c. Due to a splash point change, the RTCC and the ACR both predicted P65 would be entered. The data necessary to run simulations was given to MIT/IL at 184:00, the hybrid run results were available at 189:00. It showed no P65. At 193:45 digital simulation results were received and agreed that P65 would occur. What happened in the hybrid run is unknown.

d. The entry occurred as planned with target: 13.32° N., 169.17° W., and CMC actual: 13.30° N., 169.15° W. Splashdown was at about 195.18 although we lost CMC data in P63 at 195:03:18.

John R. Garman

Enclosures

FS55:JRG:beb

P23 COMMENTS

J. GARMAN - AGC

1. ON DAY 1 THE PROBLEMS were:
   a. BAD STATE VECTORS
   b. INCORRECT GROUND ADVISE

On ITEM "a", this caused the CMC to improperly point the spacecraft. Good marks updating the vector would have steadily improved this. Item "b" caused bad marks to be taken making the vector worse AND hence attitude worse. The crew had asked if the reticle had to be parallel with the horizon and they were told (not by AGC or GUIDO or MIT) no, via a misunderstanding. This was corrected in the enclosed recommendation sheet (made by us with concurrences and additions by all) read to the crew on day 2. By day 2, the state vector situation on the ground was improved and DAY 2 sightings were preceded by an uplink which corrected that problem.

2. Some minor procedural problems should be noted:
   a. On day 1, the crew did not properly incorporate trunnion bias readings; corrected by ~~encl~~ enclosure on day 2.

   b. We have at least twice seen Mike attempt AUTO OPTICS WITH V59 on the DSKY (trunnion calibration display). He once commented that the CMC for some reason(!) drove the SXT off the star. CORRECT, as there is no "auto optics" during calibration.

   c. On DAY 2, CMC computed attitude gave LM occultation. We suggested that he roll out of the way (to FAO) then do a V94 to recompute attitude (CMS concurred). FAO chose to read up ground computed attitude. THE CREW went to that attitude then did a V94 to have the CMC recompute and it came up with approximately the same numbers. Note that our (CMS & AGC) wish was that the crew correct the situation sans ground help - although the crew *may* now understand how to do that.

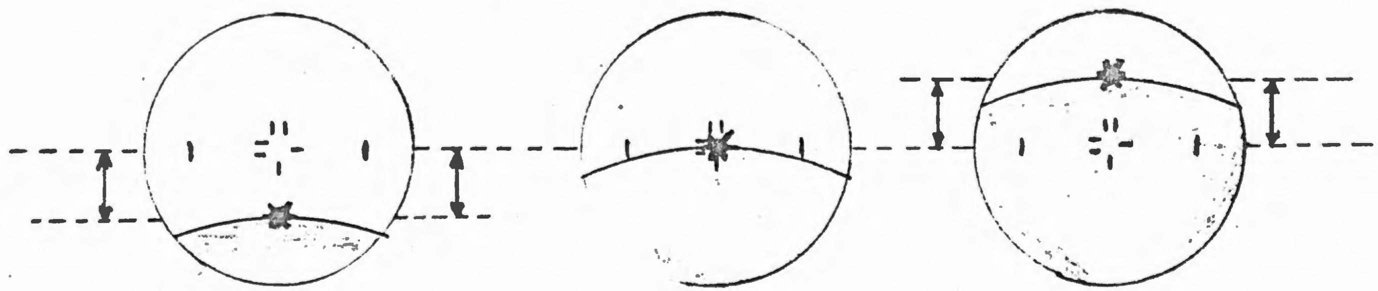
d. After the above attitude maneuver the crew commented that the reticle was *perpendicular* to the horizon. Quite possible, as the optics were zeroed and hence auto optics disabled. FAO was about to read shaft/trunnion angles up, but the crew (without ground advise) went to auto optics correcting the situation (auto optics, by the way, came up with angles very close to FAO's) and pointing the STAR LOS AT THE STAR.

e. THE CREW *SHOULD* BE ABLE TO START WITH A BAD VECTOR (and LM occultation) AND *WITHOUT* GROUND ASSISTANCE, UPDATE THEIR VECTOR. I, PERSONALLY, AM NOT SURE THEY CAN DO THIS, ALTHOUGH WE DID AT LEAST GET THE CREW ALL THE WAY THROUGH NUMEROUS SUCCESSFUL SIGHTINGS GIVING THEM SOME CONFIDENCE. WITHOUT THE LM, I'M ALMOST SURE THERE WOULD BE NO PROBLEM.

P23
RECOMMENDATIONS

I. A TRUNNION BIAS DETERMINATION SHOULD BE DONE PRIOR TO AND AFTER THE P23 SEQUENCE.
NOTE: BIAS SHOULD BE INCORPORATED (A PRO ON N87) AFTER TWO CONSECUTIVE EQUAL (.003°) MEASUREMENTS. THE TRUNNION SHOULD BE MOVED OFF A COUPLE DEGREES BETWEEN MEASUREMENTS

II. TO INSURE SUBSTELLAR POINT MARKING: THE SXT M-LINE MUST BE PARALLEL TO THE HORIZON AT THE SUBSTELLAR POINT. NOTE: THE M-LINE IS PERPENDICULAR TO TRUNNION MOTION, AND PURPOSELY IMPLIED IS THE FACT THAT: THE STAR/HORIZON SUPERIMPOSITION MAY BE MADE ABOVE OR BELOW THE M-LINE.



III. MIT RECOMMENDS USING STAR 41 INSTEAD OF FIRST 44 SET (ONLY) (BECAUSE 41 IS IN-PLANE).

IV. MARKS SHOULD BE MADE AS SOON AS POSSIBLE AFTER THE MNVR. V94 MAY BE USED ON F51 TO REDO THE MNVR.

GARMAN - AGC
LARSON - MIT
HUGHES - CMS