



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

REPLY TO
ATTN OF: FC55 (71-143)

AUG 13 1971

MEMORANDUM

TO: FC/Apollo 15 Flight Director
FROM: FC5/Guidance Officers
SUBJECT: Apollo 15 Postflight Report

I. Problems/Resolutions.

A. Prelaunch - No significant problems.

B. Launch through LOX Dump - IU and CMC navigation errors experienced during boost flight. Navigation updates were uplinked to both computers prior to TLI.

C. SIVB Lunar Impact Targeting - No significant problems.

D. Translunar Coast - Sextant trunnion bias shift observed during the first P23 sightings. A limitation on the conditions for zeroing the optics was recommended.

E. LOI/DOI - No significant problems.

F. Predescent Lunar Orbit - No significant problems.

G. LM Activation through T₃.

1. An unscheduled uplink was executed to the CMC which destroyed a preferred REFSMMAT. The desired REFSMMAT was uplinked again prior to the scheduled alignment.

2. The incorrect REFSMMAT option selected for CSM alignment prior to LM docked align. The previous REFSMMAT was considered acceptable for descent.

3. The delay in configuring for undocking caused a CMC 01703 (Tig slip) program alarm. Crew selected P47 to execute separation.

4. Initial PGNS state errors caused a southerly trajectory deviation. Crew was advised of the direction and general magnitude of the deviation prior to highgate.

H. Lunar Stay.

1. Difficulty was experienced in completing the last post touchdown P57 alignments. Problem involved erasable procedure for LGC computation of AOT angles for crew selected detent. Crew continued with sightings without the special procedure.

2. A premission value loaded in CMC P20, option 5 for oblique photography caused CSM to yaw out-of-plane. New values for "OMICRON" were determined in simulators to keep CSM X axis inplane for the future similar photography.

3. The use of P30 with P20, option 5 running in the background during mapping/pan camera activity caused attitude perturbations. The termination of P30 allowed state vector integration which blocked out the P20 attitude commands. Crew was advised to exit P30 after 30 mins use to reduce the integration time to an acceptable interval.

I. Ascent/Rendezvous.

1. An AGS/PGNS yaw attitude divergence was observed prior to lift-off. AGS azimuth data saved from the PGNS was considered in error. The ground value of AGS address 053 was loaded from the ascent pad.

2. PGNS accelerometer biases were observed during ascent powered flight. Crew was advised to trim the AGS. The biases were corrected after insertion.

3. An unexpected POOD00-type program alarm occurred in the CMC during the final braking phase. Crew continued with the docking activities without impact.

J. Post-docking Lunar Orbit - No significant problems.

K. TEI - No significant problems.

L. Transearth Coast/Entry - Unexpected attitude excursion resulted from the crew loading N20 current attitude with a desired N22 attitude. The problem occurred during the setup of a V49 attitude maneuver. The crew repeated the procedure correctly without impact.

II. Mission Narrative.

A. Prelaunch - Operations were nominal.

B. Launch through LOX Dump.

1. Velocity Residuals.

a. During launch powered flight velocity residuals indicated navigation state differences between IU and CMC. The resulting earth orbit insertion residuals were:

$$(1) \dot{\Delta X} \text{ (IU-CMC in IMU coordinates, time interpolated) } = +2.1 \text{ fps.}$$

$$(2) \dot{\Delta Y} \text{ (IU-CMC in IMU coordinates, time interpolated) } = +8.06 \text{ fps.}$$

$$(3) \dot{\Delta Z} \text{ (IU-CMC in IMU coordinates, time interpolated) } = +15.88 \text{ fps.}$$

$$(4) \dot{\Delta V}_{\text{TOTAL}} \text{ (IU-CMC in IMU coordinates, time interpolated) } = +9.07 \text{ fps.}$$

The above velocity residuals are final value points reflecting both IU and CMC error. Individual contributions require further analysis. Also trends obtained from the analog history of these quantities must be used for exacting error analysis. These trends show two unusual characteristics in the ΔX component. The first was an indication at lift-off that the IU inertial surface velocity was approximately 1.5 fps ($\Delta X = -1.5$) underspeed compared to the CMC. The second was that this same component grew to a positive value over 3.1 fps ($\Delta X = +3.1$) and then reduced to 2.1 fps ($\Delta X = +2.1$) by insertion. Conversely, the ΔZ component displayed a constant growth rate to its value of 15.88 fps.

b. Subsequent post insertion comparison of IU and CMC navigation state characteristics against the MSFN revealed errors in both systems.

2. IU Navigation Update - The IU exhibited slight overspeed characteristics as well as violation of the orbital parameter criteria used to determine the need for an IU navigation update. Parametric checks of MSFN minus IU at 00:56:00 in the orbit were:

a. CYIS006, GMT 14:30:01 (MSFN)

ICHU01, GMT 13:47:23 (IU)

$$\Delta RV \text{ (downrange position) } = -51879.54 \text{ ft}$$

$$\Delta a \text{ (semi-major axis) } = +1.221 \text{ n.m.}$$

$$\dot{\Delta v}_{\text{max}} \text{ (maximum nodal crossrange velocity) } = 4 \text{ fps}$$

b. CYL006, GMT 14:30:01 (MSFN)

ICHE003, GMT 13:57:47 (IU)

ΔRV (downrange position) = -53522.47 ft

Δa (semi-major axis) = +1.334 n.m.

$\dot{\Delta v}_{\max}$ (maximum nodal crossrange velocity) = 4 fps

c. CROX009, GMT 13:52:00 (MSFN)

ICHU004, GMT 14:29:55 (IU)

ΔRV (downrange position) = -47720.94 ft

Δa (semi-major axis) = +1.152 n.m.

$\dot{\Delta v}_{\max}$ (maximum nodal crossrange velocity) = 3 fps

Two of the three above errors exceed the premission defined IU navigation update limits along with one 3-sigma level for the 00:56:00 point. For reference these values are:

	<u>Navigation Update</u>	<u>3 Sigma</u>
ΔRV (downrange position)	23846 ft	39722 ft
Δa (semi-major axis)	0.95 fps	1.5 n.m.
$\dot{\Delta v}_{\max}$ (maximum nodal crossrange velocity)	8.4 fps	11.6 fps

The IU navigation limits were established premission based on a worse case combination of the chosen errors giving a 23-fps midcourse correction at TLI+9 hrs. A real-time midcourse correction estimate was made by MSFC HOSC and produced 28.6 fps, substantiating the error.

3. In response to the violation of the limits, an IU navigation update was performed. Two updates were transmitted. A preliminary based on Canarvon and a final based on partial stateside tracking. The same orbital parameter analysis was performed on the CMC navigation state. This analysis indicated a slight CMC underspeed at insertion but the navigation state was well within acceptable tolerances. Post insertion CMC error levels are also influenced by termination of powered flight navigation immediately at insertion and lack of a vent model estimate in the integration scheme. Investigations are still underway to determine the source(s) that induced the initial IU navigation state error. Any revelations will be extremely interesting since TLI was performed with no significant resultant error.

C. SIVB Lunar Impact Targeting - All operations were nominal.

D. Translunar Coast.

1. Optics Calibration.

a. The P23 sightings at 9:49:00 GET presented a procedural problem. The problem evolved from an observed shift in sextant calibration before and after the sightings. The pre-mark trunnion bias was -0.003° and the postmark bias was $+0.002^{\circ}$. The change in the trunnion bias was not consistent with the sighting data. The mark data confirmed the initial value. Having the crew repeat the sextant calibration was considered but decided against for lack of justification at the time.

b. The crew was observed to perform an optics zero prior to the last calibration. The trunnion angle was greater than 10° when the zero was performed. Under this condition, the drive rates incurred in an optics zero can cause the prism to bang into the hard stop. The sudden stop could possibly shift the prism, thereby changing the trunnion bias. The crew was asked to reduce the trunnion angle manually to less than 10° before performing an optics zero in P23. After considering the possible effects on alignments and landmark tracking, the limited trunnion procedure was recommended for any optics zero.

E. LOI/DOI - All operations were nominal.

F. Predescent Lunar Orbit - All operations were nominal.

G. LM Activation through T₃.

1. Uplink Over Preferred REFSMMAT - At 96:35 GET, a landing site REFSMMAT was uplinked to the CMC in the "preferred" buffer. The uplink was executed on schedule by the flight plan. In the CMC, the preferred REFSMMAT memory locations also serve as temporary storage locations for uplink data words. At 97:18 GET, an unscheduled time increment update was uplinked to tweak the CMC clock for LM activation. After the clock correction, it was realized that the P52 alignment to the preferred REFSMMAT was yet to be performed. The REFSMMAT was uplinked a second time at 98:29 GET to correct the oversight.

2. Descent REFSMMAT.

a. At AOS of rev 11, the CMC "actual" REFSMMAT was observed to be unchanged from the previous rev. This indicated the IMU had not been aligned to the preferred matrix which was uplinked twice the previous rev. On query to the CMP, it was confirmed that only an option 3 P52 had been performed vice the option 3/option 1 sequence per the flight plan.

This created a slight problem, for a REFSMMAT was scheduled to be uplinked to the LM shortly after AOS. The REFSMMAT command load was generated prior to AOS assuming the CSM alignment to the preferred matrix. Since the "docked align" technique in the checklist places the LM IMU to the same inertial orientation as the CSM IMU, the command load had to be changed. The LM REFSMMAT command load was regenerated for the actual CSM matrix while state vectors and abort constants were being uplinked. The REFSMMAT was uplinked last, thus preventing any timeline delays.

b. Now, a word about the REFSMMAT used for descent. The CSM IMU was initially aligned to the ground computed landing site orientation prior to DOI. The matrix is recomputed in rev 10 to adjust it for change in predicted PDI ignition time. The recomputed REFSMMAT was compared to the initial one. The differences in terms of gimbal angles was 0.01° P, 0.47° Y, and 0.00° R. The REFSMMAT is used by the LGC descent guidance to initially erect the guidance coordinate frame. The erection of this frame becomes unacceptable when the REFSMMAT differs from the desired matrix by 10 to 15° in pitch. Thus, the failure to align to the recomputed matrix was considered acceptable.

3. Program Alarms - Five types of unexpected CMC/LGC program alarms were observed. In the LGC following turn on, an 01105 and several 01106 alarms occurred. These were indicative of too many uprups and downrups, respectively (interfaces with the uplink/downlink systems). These alarms have been observed in past missions and are associated with noise spikes from the DUA system. During the LM docked P52 alignment, several 00112 alarms (mark/mark reject not legal at present time) were observed. These resulted from a crew procedural error of marking prior to the program being sequenced to expect marks. In the CMC, a 00404 alarm (trunnion $> 90^\circ$) occurred at the end of the P24 landing site observation pass of rev 10. This is caused by landing site passing out of view. Just prior to the actual separation burn, a 1703 alarm (insufficient time for integration, Tig slipped) occurred. The difficulty with undocking forced separation past the time previously loaded in P30. The CMP had terminated P41 to turn Ave-g off while the undocking problem was corrected. On reselection of P41 for the actual separation, current time was greater than the loaded Tig, thus the alarm. The CMP alertly selected P47 to monitor the separation burn.

4. CMC Short Burn Constant - As scheduled by the flight plan, the CMC short burn constant, Efimp + 16, was to be updated after DOI. The update is intended to reduce the CIRC burn velocity residuals. After DOI, the SPS thrust variance was evaluated to give a 1.5 fps CIRC residual with the pad loaded short burn constant. It was decided to not update the value. Prior to AOS of rev 11, however, it was addressed again. The Descent team decided to be precise and correct the value. Thus, the unscheduled update was requested and voiced to the CMP on the frontside prior to CIRC.

5. Alternate Altitude Monitor.

a. Procedures were developed prior to IM activation allowing an adequate alternate monitor of altitude for a manual landing. These procedures assumed two failures--loss of the tapemeter and loss of the PGNS guidance after high gate. The data sources to be utilized were the AGS navigation and raw landing radar measurements. The expected AGS navigation performance was considered acceptable. However, the DEDA display granularity of altitude was only to 0.1 n.m. A technique was proposed to load DEDA address 373 with a value of +50753 to allow an altitude display in hundreds of ft. This constant alteration similarly affected the scaling of approximately 20 other parameters. The most significant of these are apolune and perilune altitudes. The change was considered acceptable.

b. The display of raw landing radar slant range to the surface was determined to be available by two techniques. The first technique developed consisted of a simple, quick DSKY entry sequence, but required termination of the LGC descent programs. The procedure was to key V96E (to terminate P64/P66), key V63E (to call R04, RR/LR self test), then key V22E, 2E, PRO (to select LR option and display N66, R1 = slant range). The descent program had to be terminated since the self-test routine cannot be called during a program which uses the radar. This prompted MIT to do their thing. A second technique was developed by MIT utilizing an erasable memory program--ala P99, IM deorbit. This procedure would require uplink of four command loads prior to PDI. Both techniques were checked out on simulators and the appropriate data made available. The decision was made, however, to only consider a total PGNS platform failure. In this case, the descent programs are useless, so only the first technique was planned to be utilized.

c. As it turned out, the tapemeter worked nominally as expected. The preparation for the other eventuality did not prove an empty effort. The knowledge of what additional capability exists may prove beneficial for the future missions.

6. Descent Performance Summary.

a. Comparison of the PGNS/AGS/MSFN navigation performance during descent gave evidence of initial state error and one accelerometer bias. The initial state error resulted in MSFN/PGNS velocity errors in the crossrange and radial axes. These errors at PDI ignition were 6 fps and 7 fps, respectively. The signs of the errors indicated the actual trajectory would be to the south and low. The state error resulted from the predicted one-rev propagation applied to the rev 13 tracking. In short, the tracking obtained on rev 14 did not agree with the predicted state uplinked to the LGC as SV_2 (LM state vector) at the beginning of rev 14. The MSFN/PGNS velocity errors remained constant and were reduced to zero after landing radar velocity incorporation. Since the errors

were constant, the technique for estimating a navigation N69 for crossrange could not be utilized. A general estimate was given of 3,000 ft for the southerly deviation at highgate. The MSFN/PGNS downrange comparison showed a very small PGNS error, confirmed by the AGS, which increased to a 2-fps maximum.

b. Since the AGS receives state initialization from the PGNS, the propagation error was not reflected in the AGS/PGNS velocity comparison. In the radial axis, however, the AGS/PGNS error was 1 fps at PDI. After ignition, the error increased and was confirmed by MSFN to be in the AGS. The error was indicative of an X axis accelerometer bias. The sign and magnitude of the bias was quite unique in that the effect of the state error was cancelled by the bias. At PDI, the PGNS and AGS were slow in \dot{h} (more positive). After the bias began to grow, the AGS \dot{h} became closer in agreement with MSFN. Finally after landing radar corrected the PGNS, all three navigation sources were together in \dot{h} . The cancellation effect made an AGS \dot{h} update not required. An AGS altitude update of approximately 1250 ft was performed, however. The update appeared to be an over correction of around 350 ft. The update was made before the landing radar had completely converged in the PGNS. At touchdown, the AGS altitude was a shade over 700 ft.

c. The performance of the landing radar was nominal. Altitude and velocity lock occurred at the expected times. After settling down, the LR/PGNS Δh was in the neighborhood of +3400 ft at acceptance.

H. Lunar Stay.

1. P57 Detent Selection.

a. A little difficulty was experienced in performing the second AT-2 P57 alignment. For the LM touchdown attitude, the first star was located in the overlap of two AOT detents. A procedural error caused the program to be reselected in midstream, after the marks were taken. Then the detent overlap prompted some confusion in trying to redefine the detent selection when the star was sighted the second time.

b. In the first attempt at the alignment, the CDR ignored the LGC computed N79 cursor/spiral values for detent five. The ground recommended detent (6) was loaded in N71. The marks were taken, and the corresponding cursor/spiral values loaded. The program was then sequenced to accept marks for the second star. The N88 unit vector for the second star was not loaded but the proper detent was entered for N71. At this point, the program was reselected unnecessarily. The N88 could have been loaded after taking the marks.

c. In the second sighting of the first star, the checklist procedure to increment the LGC selected detent for N79 computation was executed. The procedure appeared not to work in that the displayed values did not change. The problem was not with the LGC. The error was in the checklist procedure which is very vague, or misleading. After loading the special data, 32533 into address 373, a V32E response was keyed. This recycled to an earlier display in the program (N70) erased the special data. In sequencing to the N79 display, the cursor/spiral values were still computed for detent five. The proper response after loading the special address should have been PRO. This would have incremented the LGC selected detent to six and reinitiated the cursor/spiral computation. The ground advised to press on, load detent six in N71, and take marks. This was done and the alignment was completed successfully.

d. At the end of each AT-2 alignment, a set of landing site coordinates are computed from the two star sightings. On observing each set, the crew was advised to reject the values or not update RLS. This advice was based on unreasonable values computed for latitude. During powered descent, the PGNS had an initial crossrange velocity error which required redesignation to the north. The P68 navigated coordinates were expected to reflect a northerly landing of the actual target site was achieved. The latitude determined in each alignment indicated an even greater northerly landing. This did not seem reasonable; thus, the recommendation was made for rejection. The various values for the landing site are summarized below:

<u>SOURCE</u>	<u>LAT</u>	<u>LONG</u>
RLS 2	26.103N	3.660E
P68	26.12N	3.70E
1st P57	26.167N	3.598E
2nd P57	26.191N	3.624E

2. Integration in P20.

a. During the mapping/pan camera pass in rev 38, P30 was used for a time-to-go display while P20, Option 5 was running in the background. The termination of P30 was noticed to be coincident with an attitude perturbation in the P20 pointing control. This perturbation was explained as the effect of state vector integration. The integration blocks out or delays the desired attitude rate computations of P20. The initial P20 rate commands after the integration were erroneous in that the computations were valid for a desired attitude at a time in the past. Thus, the magnitude of pointing error is a function of integration duration.

b. The selection of P30 prevents the periodic advance of the CMC permanent state vectors. The longer P30 is selected, the older the vectors become. For the CSM lunar stay orbit, the CMC periodic 10-minute check would integrate the vectors to current time if more than ≈ 28 minutes old. Thus, the CMP was advised to limit P30 duration to 30 minutes during the mapping/pan camera operations.

3. P20 Omicron.

a. At AOS of rev 23 while using P20, Option 5 to obtain forward oblique photos, it was noted that the CSM yaw gimbal was approximately 17 degrees out-of-plane. This caused concern since any CSM body skew with respect to the orbit plane would impact the photo strips being taken. The reason for the offset was traced to the use of +180.00 for Omicron in the P20, N78 load. This error resulted from a premission planning assumption that a +000.00 or +180.00 Omicron could be used for forward or backward CSM body pointing regardless of the pointing LOS specified in P20, N78.

b. Omicron is a 2-plane measurement being the positive sensed angle between the plane defined by the negative angular momentum vector of the orbit and the LOS, and the plane defined by the +Y CSM body axis and the LOS. It will keep the LOS inplane at a 0 degree yaw gimbal angle using +000.00/+180.00 only if the LOS is in the ZY CSM body plane. If the LOS is located otherwise, Omicron must be biased appropriately.

c. Since there was no real time or offline capability to develop or verify Omicron values remaining in the flight plan, trial and error simulations were conducted in the CMS. These simulations resulted in one subsequent change in the Omicron used for backward oblique photos in rev 34. MIT immediately initiated efforts to develop a simple equation to compute Omicron to maintain inplane conditions for a given LOS N78 definition. This effort successfully culminated after several days of intense investigation.

I. Ascent/Rendezvous.

1. Surface Preparation.

a. The initial P57 was prematurely selected without the necessary ground uplinks having been completed. P00 was selected, enabling P00 integration, which is normally inhibited at this time by bringing the LGC out of standby via a V96. As a result, the LGC detected a need to satisfy integration before acknowledging the transfer from P27 to P00 at the end of the first uplink. This integration required bringing very old state vectors, i.e., the ones current at post-descent power down, up to current time. Since this is a time-consuming process, delaying alignment activities, an abnormal V96 was executed to terminate P00 integration and allow completion of P27.

b. The AGS azimuth alignment used in conjunction with lunar align was found to be in error prior to ascent. The checklist is designed to allow the AGS to determine its azimuth alignment based on PGNS gimbal angles after the AGS/PGNS align at approximately T-00:35:00. The derivation, stored as sine (DEDA 047) and cosine (DEDA 053) values of the azimuth angle, uses the current gimbal angles. Since the ascent azimuth was approximately 283° east of north this mission, rather than near 270° , rotational cross coupling was present on the gimbals at the time of the above derivation. This cross coupling is eliminated as the IM rotates into desired body position with the IMU alignment at the time of lift-off. To illustrate the point the PGNS yaw gimbal at the AGS/PGNS align time was 356.45 degrees whereas, the desired gimbal at lift-off was 356.75 degrees. This confirms the -.11 degree of yaw misalignment detected at T-00:05:00, prompting instructions to load the ground computed cosine value, DEDA 053, provided on the ascent pad. The ground computed values are based on the preferred IMU gimbal angles that will exist at lift-off. After the loading DEDA 053 the AGS yaw alignment was within +.04 degrees of the PGNS IMU at actual lift-off. This small difference results from use of the initial P57 IMU alignment data to analytically calculate the pad values of DEDA 047 and 053. The predicted lift-off yaw gimbal angle based on the first alignment was 356.60 degrees, while the second alignment projected 356.57 degrees, hence, a difference of roughly .04 degrees.

2. Ascent Performance.

a. The ascent turned out to be rather interesting from the standpoint of monitoring the guidance systems. The PGNS had velocity errors in the downrange, crossrange, and radial directions. The residuals were well within the switchover limits but were larger than has been seen on previous missions. The PGNS residuals were, respectively, $V_x = +4$ fps, $V_y = -6$ fps, and $V_z = -9$ fps. Based upon these errors, which were confirmed by the AGS and MSFN doppler, it was requested that the AGS be trimmed at insertion. An additional recommendation was made to trim only the inplane residuals due to the AGS having an out-of-plane error that did not confirm the PGNS error. Prior to TPI, the PGNS X and Z axis PIPA biases were updated with delta values of 0.00515 fps/s and 0.0045 fps/s, respectively. This would indicate that the downrange and radial errors experienced during ascent were due to these accelerometer biases.

b. To confirm the size of the biases required to cause the residuals experienced would take postflight error studies. An additional comment might be in order here concerning the X-axis bias update. Prior to ascent the X and Y PIPA biases were updated with deltas of 0.00655 fps/s and 0.011 fps/s respectively. The biases had been computed by a new method. Only half of the computed X bias was updated because of inexperience with the method. The value updated post-insertion confirmed the amount of bias not updated which would indicate that the method of computing the biases on the lunar surface was good and that possibly most of the radial residual could have been eliminated. When looking at

the crossrange residual error several things can be pointed out. As mentioned previously, there was a misalignment of 0.04° between AGS and PGNS which would explain the AGS to PGNS out-of-plane residual error of +4 fps at insertion. In addition, the MSFN to PGNS residual indicated the PGNS had a -6 fps out-of-plane error at insertion. This subtle error possibly resulted from a P57 azimuth misalignment. The second P57 roll torquing angle was -0.057° which, if in error, would result in a -5.7 fps residual at insertion.

3. CMC POODOO Program Alarm - During the docking phase, the CMC had a POODOO alarm (21502) causing P79 to be terminated. The CMP was questioned shortly after docking if he could remember what he had been doing at the time of the alarm. He was unable to remember, but MIT was able to reproduce the condition and later verify that is what had happened. The 21502 alarm occurs due to the program trying to put two flashing displays on the DSKY at the same time, and not being able to decide which one to display, gives up and calls POO. The alarm occurred when the CMP keyed a "Proceed" to a N54 display of range and range rate called by a V83 extended verb. The normal display in P79 is the N54 range/range rate data. The usual response to the display is a "Proceed" which initiates a flashing verb 37. The CMP did key a "Proceed" but followed the response with a V83E which displayed the N54 data again. The display left a flashing verb 37 action lurking in the background. When the CMP keyed another "Proceed" to the extended verb N54 display, the CMC tried to initiate another flashing verb 37 action which is illegal in the computer. Thus, the alarm 21502 was triggered. The CMP pressed on and completed docking without further impact.

J. Postdocking Lunar Orbit - All operations were nominal.

K. TEI - All operations were nominal.

L. Transearth Coast/Entry - Loading of N20.

1. At approximately 264:14:00 two CMC N20 cells were inadvertently loaded during a V49 maneuver setup. Since these cells represent CMC DAP knowledge of spacecraft attitude the crew detected a sudden single axis attitude movement as the CMC attempted to correct for the change it saw in attitude.

2. Normal procedure is to call up N20 and copy the current roll attitude for loading with the desired pitch and yaw in N22 of V49. In this instance N20 wasn't terminated via key release, instead the N22 roll and pitch were loaded into N20 thus making the CMC believe it needed a sudden angular change to maintain attitude. Fortunately, the true attitude was near the pitch value loaded, roll was the same, and yaw wasn't loaded. The CSM was rolled approximately 90 degrees so that the erroneously loaded pitch attitude 90.00 versus 93.58 caused an effective CSM yaw body rate glitch. After verifying the above had indeed occurred a V40 N20 was requested to re-synchronize the N20 CDU cells to the IMU.

III. Recommendations.

A. An arrangement has been made to allow the crew to convey certain circumstances to the ground via the CMC/LGC downlink. The keying of selected computer verbs is the instrument of communication. Several times during Apollo 15, an unexplained V99 was observed during periods of questionable voice interface. Since the Guidance Officer position monitors DSKY activity extensively, the recommendation is made to inform the controllers of the special verb combinations. Such knowledge would better enable the observer to recognize and pass along the information to the Flight Director.

B. The difficulties experienced with the post-touchdown P57 alignments can be partially attributed to the lack of clarity in the checklist. The LM G&C checklist, page 1-40, step six mentions the special erasable procedure to force the LGC to use the next highest detent number. The proper responses after using the procedure should be more clearly specified.

C. The observed AGS yaw attitude divergence from the PGNS is suspected to have been caused by an incorrect AGS 053 value. The validity of using the 053 value saved from the PGNS needs to be further investigated for the high inclination lunar orbit missions. The results of the study may alter the surface preparation timeline for ascent.

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