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

IN REPLY REFER TO: 70-FS55-157

OCT 2 6 1970

MEMORANDUM TO: See list attached

FROM : FS/Chief, Flight Support Division

SUBJECT : COLOSSUS 2E and LUMINARY 1D program and operational notes, first edition for mission H3 (COMANCHE 108 and LUMINARY 178)

1. Enclosed is the present version of all known COLOSSUS and LUMINARY program and operational notes for the H3 mission. A description of the numbering convention is also included. These program notes consist of a list of idiosyncracies or "funny little things" that may occur during the operation of the COLOSSUS or LUMINARY programs. Notes that are considered significant (by the Flight Software Branch) and notes that originated from program anomalies are flagged to the left with an asterisk.

2. Any questions or comments should be directed to the COLOSSUS Program Engineer, Mr. G. R. Sabionski, or the LUMINARY Program Engineer, Mr. T. G. Price, both at extension 2308.

Lynwood C. Dunseith

Enclosure

FS55:TGPrice:beb

15-55

19-55

There are two restart prog notes
1) Aborted concurrent with keystroke at V16N85 display
2) @ Enter sequence to V99 before 715-0 and (b) Enter after 715-0 and prio to 1640 before 715-0

2 PM
BLDG 4 396

The numbering convention for the program notes is X.X.X, where:

A. First digit

1 = COLOSSUS Program Notes

2 = LUMINARY Program Notes

B. Second digit

1 = Nouns, verbs, displays

2 = Selection of new programs and extended verbs

3 = Ground updates and pad loads

4 = Navigation and W-matrix

5 = Rendezvous and targeting

6 = Optics, IMU, and radars

7 = Guidance and control, boost, and entry

C. Last digit, order number

Program and operational notes applicable to the H3 mission for the COLOSSUS program.

1.1 Nouns, Verbs, and Displays

1.1.1 Some nouns are not manually callable with valid data at any time, e.g., 5, 6, 7, 12, 16, 24, 25, 26, 29, 30, 34, 41, 97, 98.

1.1.2 The following nouns can never be loaded via V24 or V25: 40, 44, 45, 50, 63, 75, 80.

1.1.3 There are three priority displays in COLOSSUS which will ignore any response for two seconds:

V06N49 in R22
V05N09 in R52
V50N18 in R60 during P20

1.1.4 If P30 is used instead of V82 with time option to estimate perilune during translunar coast by loading zeros into N81, DO NOT PROCEED on N42, rather do V37EXXE. Avoidance procedure: Load 0.2 ft/sec into R2 of N81. Recognition: Arcsin alarm (code 1301). Recovery procedure: Hit error reset, then do V37EXXE.

1.1.5 When loading decimal data into the AGC, the ENTER sometimes changes the last digit of the loaded value since PINBALL roundoff in decimal/octal/decimal conversion occurs when data is keyed in (decimal to octal) and entered and redisplayed (octal to decimal).

1.2 Selection of New Programs and Extended Verbs

1.2.1 There are some abnormal consequences of restarts during IMU and Optics mode switching.

If a restart occurs (due to POODOO, BAILOUT, V37, or hardware cause) during certain portions of IMU or OPTICS mode switching, certain failure inhibit bits may remain set, preventing the program from sending appropriate alarms if a genuine failure occurs. The events during which such a restart is dangerous are summarized below.

a) IMU mode switching

1. Coarse align to fine align (including V42)
   IMUFAIL inhibit which was set during coarse align, is not removed for about 5.12 seconds.

2. IMU CDU zero (V40)
   ICDUFAIL and IMUFAIL are inhibited at start, and the inhibit is not removed for about 8.22 seconds. Bit 6 of IMODES33 is left set, disabling the DAP.

3. IMU turn-on
After the 90-second turn-on sequence is completed (No ATT lamp on)
the IMUFAIL, ICDUFAIL and PIPAFAIL are all inhibited. The IMUFAIL and ICDUFAIL inhibits are not reset for about 7.9 seconds and the PIPAFAIL inhibit is not removed for about 11.9 seconds.

4. Computer out of standby with IMU on
IMUFAIL, ICDUFAIL, and PIPAFAIL inhibits are set at start. The IMUFAIL and ICDUFAIL inhibits are not reset for about 8.22 seconds and the PIPAFAIL inhibit is not removed for about 12.22 seconds.

Recovery procedure: If a restart occurs during the specified critical intervals, the mode switching program is terminated and the inhibits are not reset again unless another mode switching, which would normally reset them, is performed.

1.2.2 During periods of high computer activity, e.g., P11, P4X with Lambert, or P20 with a targeting program, the selection of certain extended verbs (notably V82, V83, V85, V90) may result in program alarms 31201 or 31202 and extended verb activity is lost. Recovery procedure: Reselect extended verb.

1.2.3 If an extended verb has been selected during a mission program, with normal displays, the extended verb logic initially blanks the DSKY. Any response during the time the DSKY is blank would do one of the following things: a) respond to a normal mission program display underneath the extended verb; b) respond to the first display in the extended verb which could be initiated simultaneously with your response.

1.2.4 The following program sequences will cause problems:

a) P3X - P7X - P40 or P41
P3X - P23 - P40 or P41
Problem: P3X computations are overwritten. Recovery procedure: Redo P3X and then P40 or P41.

b) P40/P41 - P27 - P52
P27 - P40/P41 - P52
Problem: P27 and P40/P41 overwrite preferred computation. Recovery procedure: 1) Redo P40/P41 up to V50N18, then reselect P52; 2) reload preferred REFSMMAT from ground.

1.2.5 After V35 has been used, 10 seconds should be allowed before the PIPA's are used; hit error reset to clear fail registers.

1.2.6 Depending upon initial gimbal angles, the VECPOINT routine may result in large computed rotations about the pointing vector when the pointing vector must be rotated through about 180° (an example of this

would be in P40 or P41. If the +X axis were about 180° away from the thrust vector, the V50N18 may display a large change in outer gimbal angle.) Recovery procedure: If the computed attitude is acceptable, then simply proceed with the maneuver. If it is not, then manually maneuver in pitch and have the solution recomputed after some 20 to 30 degrees by keying PRO on V50N18 while not in CMC and AUTO.

1.2.7 V30 and V31 should be used only in P00, due to erasable memory sharing of N26.

1.2.8 Any program can be terminated: 1) at any flashing display via V34E with the following exceptions: (a) when P20 is running in the background of some other program, a V34E on a P20 display (R60 or N49 in R22) will terminate P20 only. Conversely, V34E on a prethrust program will turn off that program only but not P20; (b) V34E response to an extended verb display will terminate the extended verb and not the program running underneath.

1.2.9 Blank Major Mode lights indicate that a fresh start has been performed except in two cases. A restart with no restart phases active (no programs to be restarted) will result in a flashing V37 with the Major Mode lights blank. A V56 to kill P20 will also result in a flashing V37 with Major Mode lights blanked if P20 was the only program running.

1.2.10 V82E would result in computational difficulties in translunar and transearth coast if the time is not set to near perilune or perigee. Recognition: bad data in N42. Recovery procedure: Reselect V82E and change time.

1.2.11 If V89 is attempted during P00 with no valid REFSMMAT, a program alarm 2208 and a V37FL will result. If the IMU is off, a 2108 program alarm and a V37FL will result. Any attempt to select another extended verb with displays at this time will result in an Operator Error. The V37FL should be responded to by keying 00E before further keyboard activity.

1.2.12 Because V83 and V85 share three erasables (BASEOTV and ERADM, INCORPEX) with the lat. long routines, these extended verbs will compute and display erroneous r, $\dot{r}$ in P22 during auto optics positioning; however, θ and ψ are good.

1.2.13 Selection of the SATSTICK Routine via V46 <u>following</u> use of the RCS DAP, must be preceded by reloading the rate constants for SATURN in eras. locs. SATRATE through SATRATE + 3.

Failure to do this may result in saturated AK's when SATSTICK is reselected.

1.2.14 In ENTRY (P62-P67), V37's are inhibited after a response to "please perform separation" except a request to perform P00. To call another program, P00 must be entered first, then the desired program

called. Care should be taken, however, that P62 be reselected before entering the atmosphere, since AVEG is terminated by going to P00. Of course, after separation, GNCS DAP control can only be established by initialization of the entry DAP in P62.

1.2.15 When a new program selection is made via V37, the key release light will remain on during R00 and will not go off until the new program is started. No further keyboard activity should be attempted until the key release light goes off and the new mode lights are displayed.

1.2.16 Extended verbs are not restart protected. If the restart light goes on during an extended verb or a software restart occurs, the verb should be reselected.

1.2.17 In extended verb V67, N99 correct values to be loaded in R3 (the option code) are 1, 2, and 3. All other values except 0 are treated as 3.

1.2.18 In R03 (V48) the permissible values for R1 of N46 are:

vehicle config	A	0, 1, 2, 3 and 6
+X Quad AC	B	0 and 1
+X Quad BD	C	0 and 1
Deadband code	D	0 and 1
Maneuver rate	E	0, 1, 2 and 3

For R2 of N46, permissible values are:

Quad AC or BD roll code	A	0 and 1
Quad A code	B	0 and 1
Quad B code	C	0 and 1
Quad C code	D	0 and 1
Quad D code	E	0 and 1

If wrong values are loaded into R1, they will give results in R03 as follows:

A	4 is treated as 0. 5 is treated as 1.(MASSPROP will treat a 7 is treated as 3. 5 as a 6.)
B - D	All odds are treated as 1. All evens are treated as 0.
E	4, 5, 6, 7 are treated as 0, 1, 2, and 3, respectively.

All wrong odd values in R2 are treated as 1. All wrong even values are treated as 0.

1.2.19 In V79 (Routine 64) correct values to be loaded in N79 are as follows:

a) -8.9999 DEG/SEC $\leq R1 \leq +8.9999$ DEG/SEC (Note: If R1 = 0, at least one jet firing will be commanded due to present logic implementation.)

b) $+30$ DEG $\geq |R2| \geq +0.4$ DEG

1.2.20 Splash error (R1 of N50) may be incorrect after returning from the lunar sphere. Avoidance: Perform P21, P22, P23, or P37 prior to use of splash error. Recognition: Erroneous data on board. Ground can observe condition of LUNAFLAG (FW3B12); if set 1 the problem exists. Recovery: Perform P21, P22, P23, or P37 or clear LUNAFLAG via V25N07 as follows: V25N07E, 77E, 4000E, E. See also COLOSSUS anomaly COM 40.

1.2.21 It is possible that the response (PRO or terminate) to V06N51FL in R05 will not be recognized by the R05 program, causing V06N51FL to reappear. Anomalous behavior may then occur in one of several ways:

1) second response to V06N51FL results in blank DSKY;

2) normal flashing display reappears and response to that display results in blank DSKY;

3) normal display reappears accompanied by 31201 alarm.

Avoidance procedure: The only way to be absolutely certain that this situation will not occur is to key V96E prior to selection of R05. Otherwise, one should only select R05 when he can afford the time to perform the recovery defined below. Recovery procedure: Key V69E or reselect major mode via V37EXXE for items 1 and 2. None required for item 3. Recognition: Blank DSKY after sequence described in items 1 and 2. Program alarm for item 3. See also COLOSSUS anomaly COM 41.

1.2.22 The optics shaft has a physical stop 270° away from zero in either direction. The Auto Optics Positioning routine (R52) monitors the present shaft angle and the desired shaft angle to determine whether it is possible to achieve the desired angle via the shortest route (without hitting the stop). If it is not possible, then the following action is taken:

CMC Mode - desired shaft angle is achieved by driving the long way, in effect by unwinding the shaft.

Manual Mode - during P24 the desired shaft rate is reversed about every 1/4 second resulting in an oscillating motion.

Avoidance: During landmark tracking, when time is critical, the astronaut should be careful to avoid a potential shaft stops problem by keeping the X-Z spacecraft plane on the same side of the landmark (either northerly or southerly) throughout the pass.

If a problem has occurred then the astronaut can attempt zero optics and then CMC Mode to reacquire.

1.2.23 A mark reject during P24 could result in a 21302 P00D00 alarm or an incorrect landmark definition resulting in erroneous shaft and trunnion rate commands. Recognition: Program alarm and termination of R64 (stops pitch rate) and P24 or bad optics drive making landmark acquisition difficult. Avoidance: Either do not allow landmark updating (by setting NO. PASS = 37777) or do not press MARK REJECT button. Recovery: If 21302 alarm there is probably no recovery possible in the time available. If erroneous rates attempt to continue with marking.

NOTE: If NO. PASS is set to 4 (update landmark every fourth pass or 5.2 seconds), then the probability of occurrence is

$$\frac{.004 \text{ second}}{5.2 \text{ seconds}} = .00077$$

if the astronaut rejects a mark. See also COLOSSUS anomaly COM 46.

1.2.24 In P53 and P54, the astronaut should not select an extended verb after rejecting a mark (by keying ENTR to FV50N25R1=00016) and prior to next display of FV50N25 R1=00016. Avoidance: As above. Recognition: Failure to return to FV53 after termination of extended verb. Recovery: Reselect program or V69E. See also COLOSSUS anomaly COM 42.

1.2.25 After the PRO response to V06N89 in P24 (assuming optics mode in CMC), any computational extended verb with a priority less than 13 (e.g., V83) will be extremely slow in execution. In most cases, the extended verb will not be completed before it is time to switch the optics to MANUAL. Doing this will result in a 31211 alarm (illegal interrupt of an extended verb). The increased execution time is a consequence of the very small time delay (5cs) between successive R52 cycles in P24. Only during these intervals can the extended verb be executed.

1.3 Ground Updates and Pad Loads

1.3.1 In P27, the PRO key is now ignored whenever a load verb is in the verb lights (see PCR 791.1). Therefore, when it is desired to answer a flashing load verb with a proceed, V33E should be used rather than the PRO key. V33E should also be used during V21 on DSKY if PRO is desired during V41, V42, V43, and V55.

1.3.2 The program will ignore any attempt to load Channel 7 via the DSKY. It will not even alarm. Channel 7 is the superbank indicator and is under exclusive program control.

1.3.3 Any P27 update will destroy the preferred orientation matrix (e.g., that calculated by P40, P41), except an update of the

matrix itself. Therefore, if a preferred alignment is to be part of an update, it should be the last quantity in the sequence.

1.3.4 Downrupts may be lost at infrequent intervals during high level computer activity.

1.3.5 The lunar-solar ephemeris pad loaded data is only good for 2^{26}cs (approximately 14.5 days). If the flight lasts longer, new data must be loaded.

1.3.6 The GSOP defines HOLDFLAG to be word 80b on all lists except the ENTRY list where it is word 84b. This word is not on the lists. In its place is CDUCHKWD. See also COLOSSUS anomaly COM39.

1.4 Navigation and W-matrix

1.4.1 Taking marks on a landmark in the vicinity of the horizon and identifying the landmark as an unknown landmark, may cause either of the following to occur:

a) square root abort, termination of P22, and return to P00. Recovery procedure: Reselect P22.

b) overflow in the initialization of the landmark portion of the W-matrix, resulting in erroneous navigation calculations. Recognition of this effect is difficult. Recovery procedure (if recognized): Reject update on ΔRΔV display. Avoidance procedure: Do not use unknown landmark option of P22 for landmarks near the horizon. NOTE: It is recommended that all landmark sightings (known or unknown) be made such that the angle between the CSM-to-landmark LOS and the local vertical is less than 45 degrees.

1.4.2 The range and range rate displays (in R31 and R34) may degrade considerably at ranges below 0.3-0.5NM depending on marking schedules and resultant AGC navigation accuracy.

1.4.3 If V56 (terminate P20) is keyed in during a computation in P32, P33, P34, or P35, these computations will be restarted from the beginning.

1.4.4 If the time between the selection of P23 and the first mark in that program is greater than 1 hour, a V93E should be keyed to initialize the W-matrix. Problem: The W-matrix is initialized at selection of P23 and would build up cross-correlation terms such that the first ΔV display in N49 would be non-zero. See also anomaly report COM 16. There will be no adverse effects to the state vector if this is done.

1.4.5 In P37, ΔV solutions of <5FPS will bias TIG incorrectly. For an RCS burn of 1FPS or less, TIG could occur up to 20 seconds sooner.

Avoidance procedure: None required. Entry parameters are not sensitive to the above slip due to negligible central angle change.

1.4.6 V96E may cause significant loss of W-matrix correlation in two cases: 1) The keying of V96E after a V37EXXE from a program using AVERAGE-G and before the XX appears in the mode lights (AVETOMID); 2) The keying of V96E during a permanent state vector integration in P20 during mark processing. In all other cases, the use of V96E will cause no ill effects providing the next program selection is P00. Recovery procedure: If V96E is keyed in during the two cases described, key V93E at some time prior to the next navigation mark or VHF range input.

1.5 Rendezvous and Targeting

1.5.1 To ensure processing of the last sextant or backup mark in P20, wait for 15 seconds before proceeding. If PROCEED is done too soon, one of the last two marks may be ignored.

1.5.2 P37 targeted maneuvers from earth parking orbit will yield transfer times on the order of 2 minutes for the portion of the premaneuver orbit from apogee to perigee (negative flight path angle) when using the V-γ target line built into the program. When the premaneuver orbit is highly circular with poorly defined apogee and perigee, the short transfer time will occur whenever the flight path angle is negative.

1.5.3 All uplinked or keyed in ΔV's and target vectors must be in the same sphere of influence as the AGC determined state at TIG and TIG-30.

1.5.4 V83 and V85 displays may be meaningless at altitudes greater than 425NM for both earth and moon if these verbs are exercised. If V83 or V85 is desired, key V96E first.

1.5.5 Provided that the time of ignition, TIG, is defined to occur outside the lunar sphere of influence, P37 will always produce a conic solution although no precision solution may be possible.

1.5.6 For pre-apogee, long transit time abort, only the conic solutions in P37 may be grossly inaccurate yielding erroneous landing site coordinate displays. In addition, long integration period of perhaps 10 to 30 minutes may be experienced.

1.5.7 P37 is not restart protected. If a restart occurs, P37 has to be reselected.

1.5.8 P20 rendezvous navigation provides a priority display (V06N49) of ΔR and ΔV when the state vector update exceeds the pad-loaded erasable values RMAX and VMAX. Currently there are two problems: a) If the display is desired before every incorporation, any negative value must be set into RMAX, not zeroes; b) ΔR is computed as zero if $\Delta R<256$

meters for earth or <64 meters for moon; ΔV is computed as zero if ΔV <0.006 meters/second for earth or <0.0015 meters/second for moon. Avoidance procedure: If it is desired to observe V06N49 for each mark then RMAX should be loaded as any negative number. Recovery procedure: None. See also anomaly report COL 21.

1.5.9 The $\underline{v}_G$ or $\underline{\Delta v}$ displays in control coordinates, N85 or N83, are based on reading the accelerometers every 2 seconds. The displays, however, are asynchronous 1-second monitors. The result is a possible 1/2 to 1 1/2-second delay between the application of ΔV and the visible result.

1.5.10 The P30 predicted apogee/perigee (N42) for a nominal 170 x 60NM LOI_1 burn will be too large a number for apogee and a negative number for perigee (predicted numbers for Apollo 11 were H_A = 412.3NM, H_P = -122.2NM).

1.5.11 In R30, P21, R36, and R63, the correct values to be loaded into R2 of N06 or N12 for the option code are 1 and 2. Any other value will be treated as a 2, except P21, R36 will treat a +1, 0, and -1 as a 1.

1.5.12 The assumption is made in the rendezvous targeting routines (i.e., not P30) that the resultant perigee altitude will be less than 9999.7NM. If it is greater, then this display (N58) will become meaningless.

1.5.13 In P37, the correct values to be loaded into R2 for N06 are 1 and 2. Any other value will be treated as a 1.

1.5.14 R23 backup mark may be stored as much as 10 seconds after the astronaut keys ENTR on flashing V53 causing the mark to be erroneous. Avoidance: Ensure that a mark will not be in process at the time of the ENTR. This can be accomplished by shutting off VHF and observing that all marks have been processed prior to taking the backup mark. A possible procedure is as follows:

a) Key V88E to shut off VHF.

b) Key V54E to turn on R23.

c) Verify that all marks have been processed by reviewing V53N45 mark counters and by observing COMP ACTY light is not on solidly.

d) Center LM in backup optical device and key ENTR.

e) Key PRO to advance mark and to exit R23.

f) Key V87E to turn on VHF.

Repeat these steps for each backup optics mark. See also COLOSSUS anomaly COM 38.

1.5.15 In the normal course of events during rendezvous, a monitor of desired attitude vs. present attitude is conducted. If the difference should ever exceed 10 degrees, either the V50N18 is flashed or the uplink activity light is lit. However, if the astronaut is flying with the SC cont switch in SCS or the mode switch in FREE he will receive neither of these cues. Workaround: Monitor the mode II attitude error needles when in SCS or CMC/FREE.

1.6 Optics and IMU

1.6.1 After a fresh start, or restart, or after turning optics power on, the optics must be taken out of zero and returned to perform an optics zero since it is not the position of the switch but the change to the zero position that triggers the zeroing program.

1.6.2 If the mode switch is in CMC and AUTO or HOLD mode during R55 (gyro torquing routine) or during V42, or during execution of the gyro pulse torquing option of P52/P54, the DAP will maneuver the vehicle to follow the platform as it moves.

1.6.3 In P52 and P54, the permissible values for R2 of N06 are 1, 2, 3, and 4. Illegal values,

1, 5, 11, 15 . . . . . are treated as 1.
2, 6, 12, 16 . . . . . are treated as 2.
3, 7, 13, 17 . . . . . are treated as 3.
0, 4, 10, 14 . . . . . are treated as 4.

1.6.4 In P52 and P54, loads of angles greater than 90 degrees into R1 and R2 of N89 cause erroneous results as follows:

R1 (Lat) : 90 + X input yields 90 - X output,
but longitude is rotated 180°.

R2 (Long): 90 + X input yields -(180 - X) output.
-(90 + X) input yields +(180 - X) output.

1.6.5 During TVC, the optics may drift. To avoid this, always place the OPTICS ZERO switch to ZERO prior to P40. See also anomaly report COM23.

1.7 Guidance and Control, Boost, and Entry

1.7.1 During the trimming of Lambert derived $\underline{v}_G$, the $\underline{v}_G$ display may jump in earth environment, 0.1 - 0.2 ft/sec at transfer angles of 140°, 0.3 - 0.5 ft/sec at transfer angle of 60°, and 0.5 - 1 ft/sec at transfer angle of 30°. For moon environment these jump numbers are 0.02, 0.05, and 0.1, respectively. Recovery procedure: For transfer angles of 30° or less, trim to 0.1 ft/sec, for all transfer angles greater than 30° trim to zero.

1.7.2 During TVC control (in P40), astronaut use of the DSKY will mask possible V97 display (thrust fail display). Avoidance procedure:

Do not allow extended verb, monitor or static displays to occupy DSKY for long periods of time during TVC.

1.7.3 Following a hybrid deorbit burn with long coast times, the time to 0.05g's, TFE, will be in error by up to 4 minutes, depending on how early after the deorbit maneuver P61 is called. A recycle (V32) on N63 will improve the accuracy.

1.7.4 Because of the 0.01-second time granularity in the AGC, the calculation of small Lambert maneuvers may differ considerably from ground computations. The immediate effect, e.g., in P41, will be a different set of desired gimbal angles from those expected on the ground. The angular difference between the ground and AGC $\underline{v}_G$'s is a function of earth or moon environment, the magnitude of $\underline{v}_G$, and the active vehicle transfer angle. For 1 ft/sec maneuvers, this angular "error" could vary from $\sim 5^\circ$ (at 140° transfer) to $\sim 20^\circ$ (at 60° transfer) to $\sim 30^\circ$ (at 30° transfer) for the earth. For the moon, these angles are $\sim 1^\circ$, $\sim 3^\circ$, and $\sim 5^\circ$, respectively. For greater $\underline{v}_G$, the angular error is inversely proportional to the magnitude (approximately). Since the maximum error is 30°, the cross axis velocity introduced by performing the maneuver is $<\pi/6$ ft/sec.

1.7.5 If a roll jet fails "on" during SPS thrust, an appreciable roll excursion ($\approx 30^\circ$) may occur if all four jets are enabled. The PITCH-YAW dap will continue to function properly.

1.7.6 The Down Range Error display (N66) in P67 will be set to 9999.9NM when the vehicle state "goes past" the target. That is, under these conditions, this display will not exhibit positive down range error.

1.7.7 The TFF display in V82 may be incorrect if the return trajectory is hyperbolic. Recognition: Noun 73 in P21, R2>36339 ft/sec.

1.7.8 There is an extremely low probability of a CDU transient occurring during boost which will change the CDU readings by 11 1/4 degrees. This probability can further be reduced by not changing switches on the main panel.

1.7.9 The SPS engine will be incorrectly trimmed following an ENTR to a FV97N40 (thrust fail). Avoidance: None. Recognition: SPS Gimbal position indicators on MDP will show up the error. Recovery: Key V69E prior to reignition (PRO on FV99N40). See also COLOSSUS anomaly COM 44.

1.7.10 TGO display is discontinuous immediately after ignition. TGO is computed from the ratio of velocity to be gained over ΔV, where ΔV is the velocity change over the last time period. At ignition, ΔV will increase until it becomes fairly constant. Until this time, the ratio will behave erratically. The computation will settle in 4 to 5 seconds.

1.7.11 The engine gimbal trim angles (astronaut input to N48) should not exceed 9°.

1.7.12 During P40 when V99 is flashing and during P40/R41 when V97 is flashing, V06 occasionally appears for one flash. This happens because V97 and V99 are paste verbs. There is no recovery procedure required.

1.7.13 In P61 and P62, the permissible values for R3 of N61 (headsup/headsdown) are +1 and -1. 0 is treated as -1, i.e., roll angle of 0. All positive values are treated as +1 (180° roll angle). All negative values will give a + roll angle of the value decremented by 1. These angles are scaled in revolutions (360/16384 degrees per bit).

1.7.14 The same set of Digital to Analog Converters (DAC's) is used for coarse aligning the inertial platform and for driving the error needles. After a coarse align has been done, several erasables used in the needle drive routine must be reinitialized lest a bias error be introduced in the needle display. If the coarse align is done with the CMC mode switch in FREE (S/C control switch in either CMC or SCS), the reinitialization of the erasables will not occur while the DAP remains in FREE. In order to produce the proper reinitialization V46E should be keyed after the coarse align is complete (NO ATT LIGHT OFF).

Program and Operational Notes Applicable to the H3 Mission
for the LUMINARY Program

2.1 Nouns, Verbs, and Displays

2.1.1 The nouns that can be called at any time with valid data are: 1, 2, 8, 9, 10, 20, 21, 36, 46, 47, 48, 65, and R2 of 66 and 72.

2.1.2 Use of V30 or V31 (which uses N26 as transfer address) in programs that share N26 erasables may cause indeterminate transfer. (LNY-31) Avoidance: Use V30 or V31 only in P00. Recognition: Unexpected DSKY displays or activity. Recovery: Standard recovery (documented in crew checklist).

2.1.3 N42 values of ha and hp (in P30) are preburn predictions and will vary slightly from N44 values (post-burn estimates). N42 assumes the ΔV will be burned impulsively. The larger the ΔV, the greater the error in N42. Recognition: Difference in displays.

2.1.4 When loading decimal data into the LGC, the ENTER sometimes changes the last digit of the loaded value since PINBALL roundoff in decimal/octal/decimal conversions occur when data is keyed in (decimal to octal) and entered and redisplayed (octal to decimal).

2.1.5 There are eight priority displays in LUMINARY which ignore any response for two seconds:

V06N49 in R22
V50N18 in P20 or P25
V50N72 in P20
V05N09 in P20 (Alarm codes 501, 503, 514, 525, 526)
V06N05 in P20, P22
V16N80 in P20
V05N09 in P22 (Alarm codes 501, 503, 514, 525, 526, 530)
V05N09 in R12 (Alarm code 523)

2.1.6 The following functions are not restart protected.

a) Astronaut initiated verb/nouns
Recovery: Reselect verb/noun

b) Extended verbs
Recovery: Reselect extended verb

c) Automatic attitude maneuvers
Recovery: PRO to V50N18 that returns to DSKY after restart. If V49 or V89 maneuver, reselect extended verb.

d) Furthermore, if a restart occurs during the automatic attitude maneuver in P63, program control is transferred

back to the V50N25 display. (Please perform IMU fine alignment.) Recovery: Key in ENTER to the V50N25 and then PRO to the V50N18 that will return to the DSKY.

* 2.1.7 R3 of N40 (accumulated measured ΔV) at the end of a burn may not equal the value of R2 of N40 (VG) at the start of the burn. There are two problems:

a) If a restart occurs, the ΔV may be incremented twice in one SERVICER cycle (L-1D-06).

b) Because of an inaccurate computation of the ΔV, there will be an error of 0.34%.

There is no mission effect since only the ΔV for display is affected and not the ΔV computed for guidance.

* 2.1.7 When the DSKY is frozen by depressing a key the data in the display may be incorrect - the reason is because the guidance computer

2.2 Selection of New Programs and Extended Verbs

2.2.1 The following program sequences may cause problems:

P3X-P47-P40, P41, or P42 - The P3X computations may be overwritten. Recovery: Repeat P3X and then P40, P41, or P42.

2.2.2 If V37 is attempted within approximately 15 seconds of a fresh start of ISS turn on, a PIPA FAIL will go undetected. Recognition: None by the crew, ground support will see IMODES bit set. Recovery: Select P00. Then reset IMODES 30 bit 5 via V25N07E, 12777E, 20E, E.

2.2.3 During periods of high computer activity, the selection of certain extended verbs (notably V82, V83, V85, V90) or other DSKY activity may result in program alarms 31201 or 31202 and extended verb activity is lost. Recovery: Reselect extended verb.

2.2.4 If an extended verb has been selected during a mission program, with normal displays, the extended verb logic initially blanks the DSKY. Any response during the time the DSKY is blank would do one of the following things: a) respond to a normal mission program display underneath the extended verb; b) respond to the first display in the extended verb which could be initiated simultaneously with your response. In general, do not key a response (PRO, ENTER, V32E, V33E, V34E) to either a blank DSKY or a non-flashing display.

2.2.5 If RR is in Mode II, do not select a mission program via V37 after selecting P20 until the first R60 display in P20 (V50N18 priority display) (SDN-48). Recognition: RR may lock on in Mode II before the V50N18 if the +X axis is along the LOS. Recovery: Attitude maneuver (V50N18) will break lock, position the +Z axis along LOS, and RR will be designated to Mode I.

2.2.6 If P20 is selected prior to completion of P66 there are two problems that can occur:

a) If P20 is selected in the update mode the W-matrix initialization will destroy the E-memory descent targets.

b) RM of P20 shares E-memory location with padload "LRWH1." Therefore, if P20 is selected in the no-update mode and is allowed to proceed past the V50N72 RM will destroy the LRWH1 padload (~~L-1D-08~~). Recovery: Reload LRWH1 via V21N01E13756E XXXXXE.

2.2.7 Depending upon initial gimbal angles, the VECPOINT routine may result in large desired rotations about the pointing vector when the pointing vector must be rotated through about 180° (an example of this would be in P40, P41, or P42). If the +X axis were about 180° away from the desired thrust vector, the V50N18 may display a large change in yaw desired. Recovery: If the computed attitude is desired then simply proceed with the

maneuver. If it is not, then manually maneuver in pitch and have the solution recomputed after some 20-to-30 degrees by keying PRO on V50N18.

2.2.8 Any program can be terminated:

a) Via V34E at any flashing display except the flashing N60 in P66, the flashing N88 in P51, P52, or P57, or in P06.

b) Via V37EXXE at any flashing or non-flashing display.

** 2.2.9 When a new program selection is made via V37, the key release light will remain on during R00 and will not go off until the new program is started. No further keyboard activity should be attempted until the key release light goes off and the new mode lights are displayed.

* 2.2.10 Blank major mode lights indicate that a fresh start has been performed except in two cases. A hardware restart (caused by a V69E or a hardware failure) with no restart phases active (no programs to be restarted) will result in a flashing V37 with major mode lights blank. A V56E to kill P20, P22 or P25 will also result in a flashing V37 with major mode lights blanked if no other program is running (LNY-51).

* 2.2.11 The following extended verb routines should not be requested if P20 or P22 is running and the range to the CSM is greater than 400 n.mi. (L-1D-05).

R04	V63	LR/RR self-test
R05	V64	S-band antenna
R30	V82	Apogee/Perigee display
R31	V83	Range/Range Rate display
R36	V90	Rendezvous out-of-plane display
R47	V47	AGS initialization
	V67	W-matrix monitor
	V85	Mode II RR position display

Recognition: Erroneous displays from extended verbs. Bad AGS update if V47 requested.

* 2.2.12 A restart during AGS initialization (V47E) may leave the NODOFLAG set so that major mode change to any program except P00 is not allowed. Recovery: Reselect V47E or clear flag via V25N07E 76E1EE.

2.3 Ground Updates and Pad Loads

2.3.1 The PROCEED key is now ignored whenever a load verb is in the verb lights. Therefore, when it is desired to answer a flashing load verb with a PROCEED (as in P27) V33E should be keyed in rather than the PROCEED key.

2.3.2 The program will ignore any attempt to load channel 7 via the DSKY. It will not even alarm. Channel 7 is the superbank indicator and is under exclusive program control.

* 2.3.3 There is an inherent error in the LGC computed unit vectors for the Sun and Moon. This error is further degraded in the Apollo 14 LUMINARY program because one of the constants used in the computation of the Moon position was inadvertently misscaled by a factor of 2. The inherent Moon position error is a maximum of 1.1 degrees. The maximum as computed in the Apollo 14 program is 3.3 degrees (L-1D-11). Avoidance: If the Sun, Moon, Earth options are to be used in the LGC for an alignment, the ground should uplink the unit vectors.

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* 2.3.4 LRWH 1 B 63 ~ L-1D-13

* 2.3.4 the new N88 Bit

2.4 Navigation and W-matrix

2.4.1 A V96E can cause the W-matrix to be out of phase with the state vectors if it is performed: 1) during P20 mark processing, but only if the CSM state is being updated (V81); or 2) during AVETOMID, i.e., after responding to the FLV37 when leaving a program where Average-G was on and before the program lights change. Recovery: For 1) none needed; 2) V93E.

2.4.2 If a V37EXXE, abort button, or abort stage button is used or if a software restart occurs when the RR or LR is being read, a 520 alarm may occur. The data that was being read is not used. Recovery: ERROR RESET and continue.

+ P72, 73, 74, 75

2.4.3 If V56E or V34E on a P20 display (excepting N49) is keyed to terminate P20 during a computation in P32, P33, P34, or P35, these computations will be restarted from the beginning.

2.4.4 P20 rendezvous navigation provides a priority display (V06N49) of ΔR and ΔV when the state vector update exceeds the padloaded erasable values RMAX and VMAX. Currently there are two problems: 1) If the display is desired before every incorporation, any negative value must be set into RMAX, not zeroes; 2) ΔR is displayed as zero if $\Delta R < 256$ meters for earth or < 64 meters for moon; ΔV is computed as zero if $\Delta V < 0.006$ meters/second for earth or < 0.0015 meters/second for moon. Avoidance procedure: If it is desired to observe V06N49 for each mark then RMAX should be loaded as any negative number. Recovery procedure: None.

2.4.5 If a recycle (V32E) response to a V06N49 display is used to reject an excessive state vector update from a trunnion angle measurement (R3 of N49 = 4), the mark counter will be incremented. Avoidance: Key terminate (V34E) in response to a N49 display from the trunnion angle measurement.

* 2.4.6 With a failed on ROD switch MARK X, MARK Y or MARK REJECT functions are inhibited.

Delete

SET

MARK X, MARK Y or M

or

2.5 Rendezvous and Targeting

2.5.1 Range rate display in V83 may degrade considerably at ranges less than 0.3 to 0.5 NM depending on navigation accuracy.

2.5.2 Lambert computations should not be used within three degrees of a target vector.

2.5.3 The Vg or Δv displays in body axes, N83 or N85, are based on reading the accelerometers every two seconds. The displays, however, are asynchronous one-second monitors. The result is a ½ - 1½ second delay between application of ΔV and the visible result.

2.5.3 see 2.4.4

2.5.4 see 2.6.6

2.5.5 a P00 D00 abort with

the (1-1D-13)

2.5.6 F87 which turns P22

(1-1D-17)

2.5.7 (1-10-18) put - Nav switch

2.6 Optics, IMU, and Radars

2.6.1 If the attitude control mode switch is in AUTO or ATT HOLD with rate command/ATT HOLD selected (V77E) during R55 (gyro torquing routine) or during V42 or during execution of the gyro pulse torquing option of P52, the DAP will maneuver the vehicle to follow the platform as it moves.

2.6.2 If P20 is in progress, a hardware restart will remove TRACK ENABLE and force the program back to the beginning of the designate and attitude maneuver. Recovery: Self recovery.

* 2.6.3 If the IMU error counters are enabled when the autopilot is turned on, the FDAI attitude error needles will not be properly initialized (L-1D-01). Recovery: V40N20 with DAP on.

2.6.4 If a restart (hardware, software, or V37) occurs during IMU moding while the DAP is disabled, the DAP will remain disabled. The major problem is if a V37 is done while a V40N20 is in progress. Avoidance: Wait 15 seconds for a V40N20 to complete. Recovery: Repeat the V40N20.

* 2.6.5 If the IMU is caged or put into coarse align during pulse torquing, repeated core set overflow alarms (31202 BAILOUT alarms) may occur (L-1D-02). There is a remote chance that this could happen during AVERAGE-G if the platform goes into gimbal lock. Avoidance: Do not coarse align during AVERAGE-G. Recovery: V21N01E 1477E 40000E.

* 2.6.6 P25 cannot be used to control vehicle attitude if range to CSM is greater than 566 n.m. (L-1D-04). Recognition: After selection of P25 no attitude changes occur; possible alarm light (code 526).

* 2.6.7 If the PGNCS mode control switch is moved from ATT HOLD to AUTO just after a pitch or roll rate command is terminated and if X-axis override is inhibited, then when the X-axis override inhibit is removed the DAP will start to yaw back to the attitude at the time that the switch was moved. (L-1D-07) Avoidance: Do not switch from ATT HOLD to AUTO after a pitch or roll rate command during the parts of ascent and descent that inhibit X-axis override. Recovery: Move the ACA rapidly out of detent and back in the yaw axis when the unexpected maneuver occurs in order to establish a new yaw reference attitude.

* 2.6.8 Selection of V41N72 while an RR reposition or remode is in progress results in incorrect operation of the V41N72. Also, keying in V44 while a reposition is in progress will cause erroneous operation of a subsequent V41N72 (L-1D-12). Avoidance: Do not key V41N72 while a reposition or remode is in progress or V44 while a reposition is in

progress. Recovery: Cycle RR mode select switch from LGC to SLEW wait at least one second and back to LGC.

* 2.6.9 There are a number of windows during which a change in major mode would wipe out a waiting 1/ACCS job leaving the DAP with improper data (L-1D-10). Avoidance: The following should be avoided; 1) exits from powered flight programs after the preburn attitude is calculated that do not go through the final displays of that program; 2) termination of P20 or P25 during the execution of R23 or R60; 3) termination of R03 by a change in major mode; 4) change in major mode within a second of operating an RCS isolation value. Recovery: V48E, PRO, V34E.

2.7 Guidance and Control, Boost and Entry

2.7.1 Do not select P40 or P42 if VG $\leq \Delta V_m$ (i.e., ullage DELTA V should not exceed the total velocity-to-be-gained). The engine will be turned on for 0.01 second; may cause engine freeze-up and may be dangerous to crew safety. Recognition: R2 of N40 is less than 45000/weight prior to TIG-30. Recovery: Confer with ground.

2.7.2 In order to avoid excitation of the CSM-docked bending mode and possible damage to the docking tunnel, small steady ACA deflections with fine stick scaling (4°/sec) should be used in the ATT HOLD mode. Recognition: Perceiving a surprising increase in RCS jet activity and seeing a sinusoidal motion on the FDAI error needles (between 2 and 4 cps).

2.7.3 During thrusting programs when V99 or V97 is flashing, V06 may occasionally appear for one flash. There is no recovery procedure required.

2.7.4 A KALCMANU maneuver rate in excess of 0.5°/sec should not be used in the CSM-docked configuration.

2.7.5 For a certain range of fuel loading in the CSM-docked configuration the LM +X thrusting jets produce a negative torque due to impingement on the RCS jet plume deflectors. Therefore a disabled or failed off -X thrusting jet can cause instability in the CSM-docked control. Avoidance: Disable all deflected (+X thrusting) jets when the c.g. is above STA 364.

2.7.6 Do not load a zero or negative number in R1 or R2 of N48 (DPS pitch or Roll trim) (SDN-124). Recognition: 21204 alarm with V37 flash. Recovery: Recall present program and R03.

2.7.7 The TGO display in N40 is discontinuous immediately after ignition. The ΔV measured becomes fairly constant and the computation settles out in four-to-five seconds.

2.7.8 The crew should disable jet failures detected (or suspected) during the low-throttle period of P63 or P40 as quickly as possible. The attitude should then be carefully monitored at throttle-up. If the excursion is unacceptably large, the engine must be throttled down or stopped.