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*PROGRAM NOTES

FOR

COLOSSUS 3 AND LUMINARY 1E

J-SERIES MISSIONS

FLIGHT PROGRAMS

REV 1

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FLIGHT SUPPORT DIVISION

MANNED SPACECRAFT CENTER

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Rev 1

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FLIGHT SUPPORT DIVISION

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MANNED SPACECRAFT CENTER

Houston, Texas

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This document contains the current version of all known COLOSSUS and LUMINARY program notes for the J series (Apollo 16, 17) missions. These program notes consist of a list of anomalies found, and of idiosyncrasies that may occur, during the operation of the COLOSSUS or LUMINARY programs. Any questions, comments, or corrections should be directed to Mr. C. David Sykes (FS6) at MSC extension 2308.

The numbering convention for the program notes is *A.B.C (B) or (BC), where:

* - Denotes those program notes that are considered significant (by the Simulation and Flight Software Branch) and notes that originated from program anomalies.

A - First digit

1 = COLOSSUS

2 = LUMINARY

B - Second digit

1 = Nouns, Verbs, Displays, and Program Sequencing

2 = IMU, Optics (and Radar for LUMINARY)

3 = DAP

4 = P11, P15 (COLOSSUS)
P12, P70, P71 (LUMINARY)

5 = Rendezvous

6 = P21-P30

7 = P4X

8 = P5X

9 = P6X (Both)
P37 (COLOSSUS)

10 = UNIVERSAL TRACKING (i.e., P20 General)(COLOSSUS)

C - Last digit is order number

(B) - Denotes that this program note is both a COLOSSUS and LUMINARY note. This note in the other program section would be listed in the section with the equivalent second digit but would not necessarily have the same order number.

(BC) - Essentially the same as the above except that it is conditionally the same (i.e., basically the same note in both programs but with minor differences). The same comments as above apply here.

PROGRAM NOTES APPLICABLE TO THE J SERIES MISSIONS FOR THE COLOSSUS PROGRAM

1.1 Nouns, Verbs, Displays, and Program Sequencing

1.1.1(BC) The nouns that can be called at all times with valid data are: 1, 2, 3, 8, 9, 10, 15, 20, 21, 26, 27, 36, 38, 46, 47, 48, 65, 79, and 91.

1.1.2(BC) The following nouns can never be loaded via V24 or V25: 40, 44, 45, 50, 63, 75, 80. N95 should not be loaded, see Program Note 1.4.2.

1.1.3(B) N26 is no longer available for loading super bank bits for use with V27 to display fixed-memory. DSPTEM1 +2 must be loaded via V23N25E to accomplish this.

*1.1.4(B) The PRO key is ignored whenever a load verb (i.e., V21, V22, V23) is in the verb lights. Therefore, when it is desired to answer a flashing load verb with a proceed, key V33E or V (to blank verb lights) followed by PRO.

*1.1.5(B) Because V35 (DSKY Light Test) removes power to the PIPA's, 10 seconds should be allowed after the V35 before the PIPA's are used, and error reset keyed to clear the fail registers of the resulting 212 (PIPA FAIL) alarm.

1.1.6(B) A restart during the operation of V35 (DSKY light test) can put the IMU into coarse align. Recognition: NO ATT light on after restart. Recovery procedure: Do P51 or rapid IMU re-align procedure in checklist. See also Program Note 1.2.4.

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

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

1.1.9(BC) V82E would result in computational difficulties in translunar and transearth coast if the time is not set to near perilune or perigee because conic integration is used. Not only will V82 produce meaningless results if the input time places the spacecraft in the middle of transearth or translunar coast, but in the following specific instances, a 21302 (negative square root) POODOO abort:

a. In earth sphere when the position vector is greater than 4333NM (TEI + 1.3 hours).

b. In lunar sphere when the position vector is greater than 7743NM (LOI - 3 hours).

1.1.10(BC) In V82 (R30), the correct value to be loaded into R2 of N12 for the option code are 1 and 2. Any other value will be treated as a 2, except +1, 0, and -1 will be treated as a 1.

1.1.11 Because V83 and V85 share three erasables (BASEOTV, ERADM, and INCORPEX) with the lat. long. routines, these extended verbs will compute and display erroneous r, r in P21, P22, P24, and P29 during auto optics positioning; however, θ and ϕ are good.

1.1.12 V83 and V85 displays may be meaningless at altitudes greater than 432 NM for both earth and moon if these verbs are exercised because of sharing with the integration routines. If V83 or V85 is desired in P00 key V96E first. Recovery procedure: reselect verb.

1.1.13(BC) RTHETA displayed in R3 of N54 and N53 (V83 and V85) may be incorrect for one display cycle and, therefore, care should be taken when freezing the DSKY to insure that RTHETA was valid when the DSKY is frozen. This problem exists because the cell that is displayed as RTHETA is used to contain an intermediate value in the computation of RTHETA and, therefore, if the display should update while RTHETA contains this intermediate value the DSKY would contain the wrong number. The DSKY should not display an intermediate computation for more than one display cycle (1 second) as there is no correlation between the N54/N53 computation cycle and the display update cycle.

1.1.14(B) If V89 is attempted during P00 with no valid REFSMMAT, a program alarm 220 and a FLV37 will result. If the IMU is off, a 210 program alarm and a FLV37 will result. Any attempt to select another extended verb with displays at this time will result in an Operator Error. The FLV37 should be responded to by keying 00E before further keyboard activity.

*1.1.15(BC) V96E may cause significant loss of W-matrix correlation in two cases: (a) The keying of V96E after a V37EXXE from a program using AVERAGE-G and before the XX appears in the mode lights (AVETOMID); (b) 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.

1.1.16(BC) DSKY use masking V97 - See Program Note 1.7.3.

*1.1.17(BC) 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 a software restart and extended verb activity is lost. Recovery procedure: reselect extended verb.

*1.1.18(B) If an extended verb has been selected on top of a normal display during a mission program, 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.

*1.1.19(B) The following functions are not restart (i.e., hardware or software) protected.

a. Astronaut initiated verb/nouns
Recovery procedure: reselect verb/noun

b. Extended verbs
Recovery procedure: reselect extended verb

c. Automatic attitude maneuvers (except those called by P20)
Recovery procedure: PRO to FLV50N18 that returns to DSKY after restart. If V49 or V89 maneuver, reselect extended verb.

d. Coarse align and gyro torquing
Recovery procedure: alignment is lost, perform P51 and/or P52 or emergency alignment procedure.

1.1.20(B) 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 conversions occurs when data is keyed in (decimal to octal) and entered and redisplayed (octal to decimal). Data shown on the DSKY can be displayed as modulo the maximum value allowed or can be data from a previous calculation that was stored into the cells picked up for display. The crew is encouraged to always write over data with the desired information.

1.1.21(BC) There are 3 priority displays in COLOSSUS which will ignore any response for 2 seconds:

V06N49 in R22
V05N09 in R52
V50N18 in R60 during P20

1.1.22(B) 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.

1.1.23(BC) 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.

1.1.24 (BC) Any program can be terminated: (a) at any flashing display via V34E with the following exceptions: (1) 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; (2) V34E response to an extended verb display will terminate the extended verb and not the program running underneath. In addition, any V37EXXE or V34E in response to a program generated flashing display will terminate the MINKEY sequence; (3) V50N25 in P06; (4) N61 in P62; (5) N69 in P65. (b) via V37EXXE at any flashing or non-flashing display except with XX not equal to zero for V50N25 in P06 and in P6X programs (as described in Program Note 1.9.9).

*1.1.25 (BC) 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 REFSMMAT computation. Recovery procedure: (1) Redo P40/P41 up to V50N18, then P52; (2) reload preferred REFSMMAT from ground. See Program Note 1.1.27.

1.1.26 If a mark is rejected when the flashing V50N25/00016 is displayed during a P03, P22, P23, P51, or P52 marking sequence, the resultant display will be FLV51N25/00016 and not FLV51 alone.

1.1.27 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.

1.1.28 If the REFSMFLG is not set, selection via V37 of major mode 81, 82, 83, 84, 85, or 86 will be accepted and will be treated as the selection of P51, 52, 53, 54, 55, or 56, respectively.

1.1.29 (BC) If V37 is attempted within approximately 15 seconds of a fresh start or ISS turn on, a PIPA FAIL will go undetected. Recognition: None by the crew, ground support will see IMODES30 bit set. Recovery procedure: Select P00. Then reset IMODES30 bit 5 via V25N07E, 13336, 20E, E. See also Program Note 1.2.6.

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

1.1.31 (BC) Downrupts may be lost at infrequent intervals during high level computer activity (e.g., P40 IM-off TVC DAP).

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

1.1.33(BC) Any extended verb display (e.g., N54 in R31 or N44 in R30) will prevent normal displays from coming up until the extended verb display is terminated. Only priority displays will pre-empt the DSKY when an extended verb display is up.

1.1.34(BC) Since program alarms are frequently referenced in this document, this program note will merely attempt to clarify the program alarm structure.

Any time a program alarm is generated, the octal code identifying the alarm is stored in the FAILREGS (which can be displayed on the DSKY via V05N09) in the following manner:

If FAILREG+0 = 0 - Store the code in FAILREG+0 and FAILREG+2
If FAILREG+0 ≠ 0 and FAILREG+1 = 0 - Store the code in FAILREG+1 and FAILREG+2
If FAILREG+0 ≠ 0 and FAILREG+1 ≠ 0 - Store the code in FAILREG+2.

In other words, FAILREG+0 contains the first alarm after an ERR RSET, FAILREG+1 the second, and FAILREG+2 always contains the latest.

After loading the FAILREGS, the program illuminates the program caution light on the DSKY. Depression of the ERR RSET key on the DSKY turns off the program caution light and zeros FAILREG+0 and FAILREG+1, FAILREG+2 maintains the most recent alarm.

There are six types of alarms differentiated by the corrective action that the program takes when an alarm is detected:

LIGHT - This type alarm illuminates the PROG CAUT LIGHT and stores the code in the FAILREGS.
DISPLAY - An alarm of this type does all of the functions of "LIGHT" plus the code is automatically displayed on the DSKY (via V05N09), hence an Astro response is required for program continuation.
PRIORITY - An alarm of this type does all the functions of "DISPLAY" except with a priority display (i.e., interrupts any other display except those that are Astro-initiated). See Program Note 1.1.21.
BAILOUT - This type alarm does all of the functions of "LIGHT" plus initiating a BAILOUT; i.e., a software restart. The BAILOUT routine terminates the present computer activity and restarts it again using a prestored initialization point. All program alarms of this type have a code in the form of 3XXXX.
POODOO - Alarms of this type do all the functions of "LIGHT" and then does either a "BAILOUT" or a "POODOO." If AVERAGE-G (i.e., burn program) is running or an extended verb is active, an alarm of this type behaves

like a "BAILOUT" (note: the "BAILOUT" would clear any extended verb but would restart AVERAGE-G). If AVERAGE-G is not running and no extended verb is active, an alarm of this type executes the POODOO routine, which terminates the current computer activity and inserts a flashing V37 in the verb register, so that the Astro may reselect a program with a minimum number of key strokes.

1107 - Alarm 01107 is the only program alarm of this type. This alarm is produced when the CMC assumes the erasable memory has been destroyed. As a result, all of the functions of "LIGHT" are performed plus a "fresh start" is initiated. A "fresh start" initializes certain parts of erasable memory to pre-programed values and leaves the CMC in "negative P00" (i.e., no program and a blank program register).

1.2 IMU and OPTICS

* 1.2.1 Coarse alignment of the IMU prior to CSM-SIVB separation while the L/V control switch is set to "CMC" and with the SIVB Take-over Relay enabled will result in driving the Saturn IV control system.

The IMU will be coarse aligned by:

a. T4RUPT if GLOCKMON sees |CDUZ|>85 degrees if AVEGFLAG is off. (Note: T4RUPT will not cause coarse align if AVGFLAG is on AND Saturn DAP is selected in DAPDATR1.) (This can take place during Earth Orbit coast due to CDUZ transients, or if Saturn actually maneuvers into gimbal lock region.)

b. Execution of V41N20E, or selection of coarse align in P52 or similar program.

Problem avoidance: Place the L/V control switch in "IU" position prior to V41, or selection of an IMU realignment program.

Recovery procedure: Place the L/V control switch in the "IU" position. Complete realignment of platform before Saturn control is re-established.

Note that this problem is confined to coasting flight due to operational constraints (no V41 or P52, etc., during boost) and that GLOCKMON will not coarse align IMU if DAP CONFIG = SATURN and AVEGFLAG is on.

1.2.2 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 or switch to HOLD or AUTO after the coarse align is complete (NO ATT LIGHT OFF).

1.2.3(BC) 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.

1.2.4(BC) A hardware restart during small windows in T4RUPT may leave garbage in certain bits of IMODES30, IMODES33, OPTMODES, and DSPTAB+11D. A restart during V35 may leave garbage in DSPTAB+11D. The effect of incorrect bit settings is summarized as follows.

IMODES30 Bits 1, 3, 4, 5	Incorrect ISS warning indication or incorrect inhibition of true ISS warning.
IMODES30 Bit 9	Erroneous IMU turn-on sequence with associated caging of ISS.
IMODES33 Bit 5	Incorrect indication of IMU zeroing on downlink.
OPTMODES Bits 4, 5	No effect
DSPTAB+11D Bit 4	Erroneous IMU moding into or out of Coarse Align.
DSPTAB+11D Bit 6	No effect
DSPTAB+11D Bit 9	Erroneous change to program alarm light.

1.2.5(B) If the IMU is on and in the Coarse Align mode when the AGC is put into STANDBY, the IMU will become inertial, and will return to the Coarse Align mode after coming out of STANDBY. The NO ATT light will remain on during the STANDBY period, however. If the IMU were coarse aligned because of Gimbal Lock, going to STANDBY could damage the IMU.

*1.2.6(BC) There are some abnormal consequences of restarts during IMU mode switching.

If a restart occurs (due to POODOO, BAILOUT, V37, or hardware cause) during certain portions of IMU 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. Coarse align to fine align (including V42)
IMUFAIL inhibit which was set during coarse align, is not removed for about 5.12 seconds.

b. IMU CDU zero (V40E)
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.

c. 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. A V37EXXE is locked out for 7.9 seconds after the IMU turn-on sequence is completed.

d. 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. A V37EXXE is locked out for 8.22 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.

*1.2.7 During TVC, the optics may drift. To avoid this, always place the OPTICS ZERO switch to ZERO prior to P40. See also Anomaly Report COM 23.

1.2.8 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.

1.3 DAP

1.3.1 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 5 as a 6.)
7 is treated as 3.

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.

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

* 1.3.3 Do not perform VECPOINT or KALCMANU (automatic pointing maneuver routines) when the SATURN DAP is selected or before selecting the SATURN DAP. Use of these pointing routines overwrites the Saturn rate change erasables (i.e., number of pulses loaded into error counter for RHC deflection) which are padloaded. Recovery procedure: Reload cells 3310 - 3312 to the prelaunch values or perform procedure on checklist page L/2-31.

* 1.3.4 The CSM/Ascent Stage TVC DAP is unstable for a near empty Ascent Stage (i.e., fuel tanks near empty). Avoidance: Load the CSM DAP for CSM alone with the combined CSM/IM weight in the CSM slot any time the Ascent Stage alone is attached, regardless of APS propellent level.

1.3.5(BC) 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.

*1.3.6 After the CMC has stopped an auto maneuver (R60) due to CDUZ exceeding ±75°, any manual maneuver to an attitude with CDUZ still greater than ±75°, followed by putting the RHC back in detent causes the CMC to drive the spacecraft back to the point where it originally went into attitude hold. This anomaly occurs when the CMC mode switch is in either HOLD or AUTO. See also Anomaly Report ART 14.

*1.3.7 The logic used in an automatic maneuver (R60) to avoid gimbal lock does not guarantee that the CDUZ will not reach +85 degrees (and hence coarse align the IMU). If CDUZ exceeds ±75 degrees during an automatic maneuver, the RCS DAP (either CSM alone or docked) will stop the maneuver. Since the actual DAP reference could be leading CDUZ by the deadband times 1.4 (CDUZ ≤1/sin 45°· DB), CDUZ could traverse through an angle equal to twice the deadband times 1.4. Therefore, if the selected deadband is greater than 3.5 degrees, CDUZ could drift beyond ±85 degrees resulting in gimbal lock.

*1.3.8(BC) V40E disabling DAP. See Program Note 1.2.6.

1.4 P11, P15

*1.4.1 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 FDAI switches on the main panel.

1.4.2 N95 (P15 display of TF GETI/TFC, VG, VI) should not be loaded, although a data load of R1 (octal), R2 or R3 will not generate an operator error.

1.5 Rendezvous

*1.5.1(B) P20 rendezvous navigation provides a priority display (V06N49) of ΔR and ΔV when the state vector update exceeds the pad-loaded erasable values RMAX or 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 $\Delta V < 0.006$ meters/second for earth or <0.0015 meters/second for moon. See also Anomaly Report COL 21.

1.5.2(BC) The range and range rate displays (in V83 and V85) may degrade considerably at ranges below 0.3-0.5NM depending on marking schedules and resultant AGC navigation accuracy.

1.5.3 The decision, based on a computed range of 327.67NM, to activate VHF ranging, may be erroneous for two reasons:

a. P20 estimate of range is derived from onboard state vector conic extrapolation and thus may be inaccurate.

b. If attitude at current time indicates that an R60 maneuver is required, and if extrapolation to the projected time of the completion of the maneuver indicates that attitude at that time will be within acceptable limits and the maneuver is not required after all, the range determination is based on the state which has been extrapolated into the future. However, if the actual distance is >327.67NM and VHF ranging is activated, N49 should be seen.

* 1.5.4 If a priority display appears after N12 has been loaded in V57, the subsequent FLV04N12 display should be answered via V32E to insure desired flag setting. (A third display of N12 will appear; PROCEED response will then exit the routine.)

Proper values to load in N12 are 0 and 1, all other values will be interpreted as 1.

* 1.5.5 Initiation of P31 - P36 or P79 at the conclusion of P40, P41, or P47 when P20 rendezvous option 0 or 4 is not already enabled (that is, RNDVZFLG not set) will result in initiation of P20 followed by an attempt to initiate an unknown major mode causing an operator error or bad major mode following P20. Recovery procedure: Reselect desired major mode. See also Anomaly Report ART 01.

1.5.6(BC) P31 is the only rendezvous targeting program known to be inoperable in earth sphere, however, due to a lack of verification testing no rendezvous targeting program should be attempted in the earth sphere of influence. There is also a known problem with the aim-point transfer between P34/P35 and P40/P41 when in earth sphere.

*1.5.7 If alarm 600, 601, 602, 603, 604, 605 or 606 occurs during P31 (alarms 603 and 604 are not locked out) and P31 is not then continued (with altered input) as far as the N90 display, or if P31 is exited via V37EXXE after the response to FLV16N45 and before the N90 display, P32/P72 subsequently will not execute its own sequence but will branch into the P31 program. Recognition: A N33 (HAM tig) display (from P31) will be displayed after N37 in P32/P72. Recovery procedure: (a) Clear HAFLAG via V25N07E, 107E, 100E, E; or (b) execute P31 to completion of computations (display of V06N90) and then select P32/P72. See also Anomaly Report ART 06.

*1.5.8 In P32 during MINKEY an incorrect value of NN will be displayed in N55 if multiple CSI's are being executed with NN greater than 4. Recognition: R1 of N55 in P32 will display NN=1 instead of the proper decremented value. Recovery procedure: Reload R1 of N55 in P32 with the proper value of NN. See also Anomaly Report ART 02.

*1.5.9(BC) If P32/P72 is terminated prematurely because of a program alarm, for example, it is not possible to execute P33/P73 using normal procedures. Unless P32/P72 is completed to the extent of PROing on N82 (N81 if MINKEY), TPI time, a required input to P33/P73 is not stored in the register used by P33/P73 (TTPIO). P33/P73 at initialization takes the value stored in TTPIO and stores it in TTPI, the register from which N37 is displayed. Therefore, it is possible using the following procedure to recover and execute P33/P73.
At the first V16N45 display in P33/P73, Key V25N37E and load the nominal TPI time.

In addition if P32/P72 was not executed at all or if the alarm occurred because of a bad elevation angle it is necessary to Key V22N55E and load the nominal elevation angle.

P33/P73 will then have all its required inputs available.

*1.5.10 If P34, P35, P74 or P75 is selected and is allowed to proceed past the V06N81 final comp display, selection of another (PRE-TPI) MINKEY targeting program will result in incorrect data for the following P76, and incorrect automatic W-matrix initialization sequencing. Recognition: An unacceptably long comp cycle after P34 or incorrect VG (other vehicle) display during P76 in V06N84. Long comp cycle can be confirmed by observation of N38 (time stepping backwards). Recovery procedure: Load correct data in P76 and clear TPIMNFLG (V25N07E, 106E, 4E, E). Pre-P76 computation may be excessive in length and may be terminated via V96E followed by selection of P76. See also Anomaly Report ART 07.

1.5.11 If N81 in P36 is set to 0 either via the DSKY or the program to bypass the plane change maneuver, a 01301 alarm (arc sine-arc cosine argument too large) can be produced after the PRO on the N81. Recovery procedure: Key RSET and PRO on the FLV16N45 to bypass the maneuver and continue the MINKEY sequence at plane change sequence III (i.e., skip P52 - P40/P41 - P52 and continue at P76).

1.5.12 P79 does not reinitialize R1 of N78 to the nominal zero value. If the astronaut has previously loaded this register with a non-zero value, he should correct it for P79 operation.

1.5.13 If P79 is selected when REFSMFLG = 0, the program will not function, although 79 will appear in the mode lights.

*1.5.14 The Post-P52 Attitude maneuver for the plane change burn may attempt to go through gimbal lock while going to its final burn attitude. If this occurs, the astronaut should manually maneuver to the desired attitude. The post burn attitude maneuver back to the tracking attitude must then also be done manually, before responding to the V50N18 flashing request. Premature response to this display will result in the vehicle going to ATT HOLD when MGA $>\pm 75^{\circ}$, and immediate entrance to P52, resulting in undesirable attitude and loss of N18 information. Manual takeover after responding to FLV50N18 will also cause immediate entrance to P52. Recovery procedure: Manually maneuver vehicle to be in-plane before responding to P52 display. Note: Mode II needles cannot be used during this period as N22 is overwritten with P52 information.

1.5.15(BC) If V56E (terminate P20) or V34E on a P20 display is keyed in during a computation in P31, P32, P33, P34, P35, P36, P72, P73, P74, or P75, these computations will be restarted from the beginning.

1.5.16 It takes approximately 15 seconds to process a mark, therefore, the astronaut should wait 15 seconds following the last mark before beginning the final comp cycle (first PRO on FLV16N45) or terminating the backup marking sequence (PRO on FLV53N45).

1.5.17 If a mark is to be rejected, MARK REJECT should be done within 7 seconds after the mark is taken, otherwise, the mark data may be processed and the vector updated.

1.5.18(B) The assumption is made in P34/P74 that the resultant perigee altitude will be less than 9999.7NM. If it is greater, then the N58 R1 display will become meaningless.

1.5.19 A MINKEY CSM-active RCS burn could be misinterpreted as a LM-active burn if the THC is deflected for less than 2 seconds.

N84 in P76 in this case will not display zero, and should be zeroed before continuing in P76.

1.5.20(B) Lambert computations should not be used within 3 degrees of a target vector.

*1.5.21(BC) V96 causing rendezvous W-matrix to be out of phase. See Program Note 1.1.15.

1.5.22 A priority display in P20 occurring simultaneously with the completion of extended verbs with displays during targeting and during astronaut keystrokes may cause a 21206 POODOO alarm. Recovery procedure: Self recovering; the POODOO terminates the extended verb and any astronaut initiated displays. Avoidance: Do not make keystrokes between the response to the last display in extended verbs and the next display on the DSKY under the above conditions.

1.5.23 A 21502 POODOO alarm will result if R31 (V83), while running on top of a FV37 from P79, is terminated with a PRO. This problem of conflicting FV37's is unique to P79.

*1.5.24 A restart during the "comp cycle" following a response to V16N45 in a targeting program locks out R61 (tracking attitude) and R52 (auto optics), and possibly R22, until the "comp cycle" is finished. See also Anomaly Report ART 15.

1.5.25(BC) The display of out-of-limits state vector updates in the CMC (N49) by P20 navigation routines involves a high priority tight loop which waits for response to the display. The effect is that all other P20 activities (specifically tracking and VHF marking) cease until a response to the display is received.

*1.5.26 Under abnormal program usage, it is possible that R31 (R, $\dot{R}$, and θ) will not be started in P79. If the first R60 is bypassed (ENTR on FLV50N18) and then immediately (in less than 2 seconds) V58E is keyed to get the FLV50N18 back before the program has started R31, and then the program remains in R60 until R31 is called (usually within 4 seconds), then R31 will find the DSKY in use with a priority display and exit. In addition, if the R61 display is V06N18 (resulting from PRO on FLV50N18) the DSKY will blank before the maneuver is finished. Avoidance procedure: Do not bypass R60, or wait for N54 before V58E. Recovery procedure: Key V83E after second R60 ends. See also Anomaly Report ART 16.

*1.5.27 P79 is not correctly restart protected. A restart causes P79 to be restarted by both restart groups 1 and 4 which in turn causes: (a) operator error when the second R31 call is made; (b) R61 to operate at twice normal frequency if the tracking error is <10 degrees; and (c) for tracking errors ≥10 degrees, conflicts in the use of KALCMANU can cause incorrect tracking, increased fuel usage, and lighting of uplink activity light during R60. Recovery procedure: Reselect P79 via V37E79E following any restart in P79. See also Anomaly Report ART 17.

*1.5.28 It is possible for R22 (P20 mark processing routine) to process an R23 (COAS) generated mark as a sextant mark if a restart occurs after the ENTR response to the FLV53N45 display, and before the next mark is taken. No avoidance or recovery procedure is required as the only effect is a possible N49 and/or a slightly degraded state vector due to using the sextant variance for the mark incorporation. See also Anomaly Report ART 18.

1.6 P21 - P30

1.6.1 The recycle option of P21 will result in conic rather than precision extrapolation of the state vector if the following extended verbs have been executed:

V64 (R05);
and { V83 (R31) } if SURFFLAG is not set.
{ V85 (R34) }

1.6.2(BC) In P21/P29, the correct values to be loaded into R2 of N06 for the option code are 1 and 2. Any other value will be treated as a 2, except +1, 0, and -1 will be treated as a 1.

1.6.3 Taking marks on a landmark (P22) 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 display of F37. 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.

1.6.4 Although no known problems exist, P22 should not be used in the earth's sphere due to a lack of verification testing.

*1.6.5 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 more than 1 hour elapses between P23 selection and the mark.

1.6.6 In P23 the optics calibration angle (N87) cannot be changed by manually loading N87. If it is desired to change the calibration angle by a means other than taking another mark, V22N94 can be used at the N87 display to load the desired angle.

*1.6.7 It is possible for P24 to attempt to update its estimate of the landmark using cells which do not contain meaningful information. Avoidance procedure: Set the pad-load cell NO. PASS = 37777_8. See also Anomaly Reports ART 09 and ART 11.

*1.6.8 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.

*1.6.9(BC) 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. The expected values in N42 for Apollo 16, 17 LOI burn are approximately: ha = 377.2NM, hp = -113.4 NM.

1.6.10(BC) If P39 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/second into R2 of N81. Recognition: Arcsin alarm (code 1301). Recovery procedure: Hit error reset, then do V37EXXE.

1.6.11(B) 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.

1.7 P4X

1.7.1 Due to roundoff in the P40 preburn VG calculation (half-burn arc rotation), LOI VG_{LV} will be in error by approximately the following amounts:

$$VGX_{LV} = -0.67 \text{ fps}$$
$$VGZ_{LV} = +1.70 \text{ fps}$$

1.7.2(B) The TGO display in N40 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.

1.7.3(BC) During TVC control (in P40), astronaut use of the DSKY will mask a 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.

1.7.4 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.

1.7.5(BC) During P40 when V99 is flashing and during P40/R40 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.

1.7.6 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 angle 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.

1.7.7(B) 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 ~5° (at 140° transfer) to ~20° (at 60° transfer) to ~30° (at 30° transfer) for the earth. For the moon, these angles are ~1°, ~3°, and ~5°, 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.

1.7.8(B) The $\underline{v}_G$ or $\Delta\underline{V}$ displays in body axes, 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.

1.7.9 If a restart occurs simultaneously with a keystroke during the display of FLV16N85 in P40 or P41, the display may disappear leaving a blank DSKY. Recovery procedure: Key in V16N85E manually if desired; exit via V37EXXE rather than the normal PRO.

1.7.10 If a restart occurs simultaneously with a keystroke during the display of FLV16N40 in P40, the display may disappear leaving a blank DSKY. Recovery procedure: Key in V69E to restore FLV16N40 and normal program sequence.

1.7.11 The VGTIG cells (used to compute VGIMU's on the ground) are shared by many programs. The parameter sharing the erasable cells with VGTIG that is of most concern is MARKBUF1. MARKBUF1 is a series of seven cells used to contain mark data in P20, P23, P51, P52, P53, and P54. The first cell of MARKBUF1 (which is VGTIGY) is set to -1 by a MRK REJ, V86 (reject rendezvous backup sighting mark), by the above programs, and by V37. Therefore, the displayed values of VGIMU will be invalid on the ground once P40 is exited (all three values of VGIMU will be invalid although only VGTIGY is invalid due to the REFSMMAT transformation). Also, once P40 has been selected V86E should not be done as VGTIG is the value of the VG to be burned by the computer.

1.7.12 If a restart (hardware or software) occurs while AVERAGE-G is running, the ΔV may be incremented twice in one SERVICER cycle. There is no mission effect since only the ΔV for display is affected and not the ΔV computed for guidance.

1.8 P5X

1.8.1 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.

1.8.2(BC) 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.

1.8.3 If doing P54 with P20 option 2 active, caution should be exercised as the mark request (ENTER on the FLV53) may not get processed immediately. This delay is due to R67 (P20 option 2 loop) having a higher priority than R56 (alternate LOS sighting mark).

*1.8.4(BC) Sightings on two celestial bodies provide 4 degrees of freedom and only 3 are needed in the alignment programs. The programs are designed to use 2 degrees of freedom provided by the first celestial body and use only the azimuth of the second body (about the line of sight to the first body) for the third degree of freedom. Thus, the first target sightings should be on the most accurately known source. For the CMC the hierarchy of optical targets is: stars, earth/moon, sun, planets.

1.9 P37, P6X

1.9.1 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.

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

1.9.3 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-Y 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.

1.9.4 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.

1.9.5 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.

1.9.6 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.

*1.9.7 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. See also Anomaly Report COL 91.

1.9.8 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).

1.9.9 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.

*1.9.10 There is a possibility of the upcontrol L/D iterator anomaly occurring during entry. These areas are the P65-P66 sequencing part and the upcontrol/no-upcontrol sequencing area. Recognition: Ground personnel can predict the unexpected program sequence and warn the astronauts. (If P65 was predicted to occur and does not, the problem exists.) Avoidance procedure: Ground personnel will retarget entry to avoid the 1215 to 1455NM range. In the "no voice" case, a nominal entry range should be flown, unless otherwise directed previously by ground personnel. Workaround procedure: Switch to manual and fly the EMS until present velocity goes subcircular in P67 and the EMS, then switch back to CMC control if no other problems exist. See also COLOSSUS Anomaly COM 43.

1.9.11 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 downrange error.

1.10 Universal Tracking (i.e., P20 General)

* 1.10.1 If the astronaut selects the FREE mode or SCS control during P20 options 0, 1, 4, or 5 the desired attitude is computed but the test for R60 is never made and, therefore, neither the Uplink Acty light nor the FLV50N18 will appear if the attitude deviation is unacceptable.

Workaround: Monitor mode II FDAI attitude error needles when in SCS or CMC/FREE.

* 1.10.2 In P20 options 0 and 1 the 10° check in R61 is made by differencing the DAP reference attitude and the desired attitudes; therefore, the actual vehicle tracking error could exceed 10° by as much as the DAP deadband before the Uplink Activity light is lit. Also, when the desired attitude is within 10° of the present attitude, it is possible that the Mode II needles could indicate an attitude error about the pointing axis which is different from the Mode I needles. In fact, Mode II needles could be inside the deadband while the Mode I needles indicate values that are not less than the deadband and, therefore, jets could be fired.

In P20 options 4 and 5 the 10° check in R61 is made by differencing the present CDU's and the desired CDU's; therefore, the Uplink Activity light will be lit when the actual gimbal angle error exceeds 10° in any gimbal axis.

1.10.3 The proper option codes to load in P20 are 0, 1, 2, 4, and 5. If a 3, 6, or 7 is loaded, the program will treat it as a 2.

1.10.4 To start up PTC, the following procedure is recommended.

a. Select .5° DB and maneuver to start up attitude

b. Disable all jets on two adjacent quads

c. Wait 20 minutes for rates to damp

d. AUTO RCS SEL (2) - MNA or MNB as follows:

+ROLL	-ROLL
A1, C1	A2, C2
or B1, D1	or B2, D2

Remaining AUTO RCS SEL (14) - OFF
MAN ATT (ROLL) - RATE CMD

e. Perform P20, opt 2 (G/8-1 CSM G&C Checklist)
Use 0, 0, 0 in N78 and 0.4200 in N79 R1 and 0.50 in N79 R2, and 0, 0, 0 in N34. Prior to final PRO: cycle CMC MODE - FREE/AUTO

f. After one jet firing: MAN ATT(ROLL) - ACCEL CMD (Note: about 3.5 seconds between 1st and 2nd firings.)

g. Disable RCS and terminate P20.

AUTO RCS SEL (16) - OFF
ROT CONTR PWR DIR (2) - OFF
V56E

1.10.5 If the RHC is deflected and then returned to detent during the reinitialization pass of R67 (P20 option 2), it will be ignored. This pass occurs once every 2048 seconds, and has a duration of about 1 second. Recognition: Automatic rotation continues after RHC has been deflected. Recovery procedure: Repeat RHC action.

*1.10.6 Vehicle rates established in option 2 of P20 will not stop by selecting ATT HOLD. Recovery procedure: Stop motion by taking RHC out of detent. See also anomaly report ART 08.

1.10.7 Starcode of 77777_8 in N70 of P20 options 1 and 5 will result in the bypassing of the N88 display. Later processing will assume starcode 0 and will use old N88 values. Avoidance: Do not load star code = 77777_8.

*1.10.8 Option 1 of P20 will not operate correctly for star (starcode = 1-45) if the LOS to the star is initially within 10° of the desired spacecraft vector. Recognition: No FLV50N18 display. Recovery procedure: Manually maneuver the spacecraft until uplink acty light comes on, then Key V58E. Workaround: Use option 5 of P20 for stars 1 through 45. See also Anomaly Report ART 12.

*1.10.9 P40/P41 will select R03 deadband instead of 0.5 degree deadband if P20 is running when P40/P41 is selected. Workaround: If P20 is to use a 0.5° deadband, then R03 should be loaded for 0.5° as usual but if P20 is to use e.g., a 5° deadband, then R03 should be loaded for 0.5° and then, after entering the first targetting program, the astronaut should load V22N79E + 500E. No other action is required. See also Anomaly Report ART 10.

*1.10.10 Selection of P47 during P20 will destroy the contents of N78 and the low half of AGEOFW (time of last W-matrix reinitialization, N31). Recognition: Incorrect value in N78 or if not noticed bad tracking or rotation. Recovery procedure: Reload N78. See also Anomaly Report ART 03.

*1.10.11 If P20 (rate computation) is forced to wait for use of the orbital integration routine (because another user is using it), the wait is not taken into account when the computations are finally made. That is, it computes rates for where the vehicle was when it first tried to integrate, rather than for where it is now. In the case of periodic POO integration of both state vectors, the pointing vector can be in error by up to .9° when using P20 option 5. Avoidance procedure: Do not manually call programs or extended verbs that use the orbital integration routine if tight pointing control is desired; or go to FREE when integrating and do not return to AUTO until 5 seconds after integration is complete.

*1.10.12 There are several instances in the programs where the deadband is automatically narrowed, but the program is unsuccessful in recentering the narrowed deadband around current attitude to prevent jet firings. The visible effect in these cases is a momentary centering of the attitude error needles at the time the deadband is narrowed, followed by an immediate return to their original positions accompanied by jet firings. In all cases, the problem is due to HOLDFLAG being left in a negative state so that the DAP restores the CDUXD's into THETADX's. The cases are: (a) selecting P40 or P41 while P20 rate drive is operating in a deadband larger (e.g., 5 degrees) than the R03 deadband (e.g., .5 degree). The resultant deadband is the R03 deadband due to note 1.10.9; (b) selecting any non-tracking program while P20 rate drive is operating in a deadband larger than the R03 deadband; and (c) selecting P40 or P41 following a V49 maneuver with the R03 deadband at 5 degrees (i.e., R03 deadband is larger than the P40/41 resultant .5-degree deadband). Avoidance procedure: Move mode switch out of AUTO before collapsing the deadband. See also Anomaly Report ART 13 Rev. 1.

PROGRAM NOTES APPLICABLE TO THE J SERIES MISSIONS FOR THE LUMINARY PROGRAM

2.1 Nouns, Verbs, Displays, and Program Sequencing

2.1.1(BC) The nouns that can be called at all times with valid data are: 1, 2, 3, 8, 9, 10, 15, 20, 21, 26, 27, 36, 38, 47, 65, R1 of 45, R2 of 46, and R2 of 66.

2.1.2(BC) The following nouns can never be loaded via V24 or V25: 40, 44, 45, 61, 62, 64, 66, 68, 74, 75, 77, 78, and 94.

2.1.3(B) N26 is no longer available for loading super bank bits for use with V27 to display fixed-memory. DSPTEM1+2 must be loaded via V23N25E to accomplish this.

* 2.1.4 The DAP configuration code that occupies the first register of N46 can only be displayed or changed effectively in Routine 3. However, the in-bit override that occupies the second register of N46 can be displayed and changed either in Routine 3 or without it.

2.1.5 N48 loading - See Program Note 2.3.14.

2.1.6 The maximum unit vector that N88 will accept is .99996. Any value greater than that will result in an operator error. An MIT/SDL investigation of the planets and the 1078 stars in the American Ephemeris and Nautical Almanac indicates that no celestial bodies will present a problem for Apollos 16 or 17.

2.1.7 P77 displays ΔV via N81. P76 displays ΔV via N84. To recall the loaded ΔV N84 should be used by both programs. The N81 values in P77 are stored in N84 after the PRO on N81.

* 2.1.8(B) The PRO key is ignored whenever a load verb (i.e., V21, V22, V23) is in the verb lights. Therefore, when it is desired to answer a flashing load verb with a PROCEED, key V33E or V (to blank verb lights) followed by PRO.

* 2.1.9(B) Because V35 (DSKY Light Test) removes power to the PIPA's, 10 seconds should be allowed after the V35 before the PIPA's are used, and error reset keyed to clear the fail registers of the resulting 212 (PIPA FAIL) alarm.

2.1.10(B) A restart during the operation of V35 (DSKY light test) can put the IMU into coarse align. Recognition: NO ATT light on after restart. Recovery procedure: Do P51 or rapid IMU re-align procedure in checklist. See also Program Note 2.2.3.

*2.1.11 R77 (V78) LR Spurious Return Test Routine must be terminated with V79 prior to the start of Average-G at TIG-30 in P63.

The IM velocity will be in error by about 50fps due to the omission of the state vector updating until a 31201 or 31202 BAILOUT clears out the R77. See Anomaly Report L-1E-06.

* 2.1.12(BC) During periods of high computer activity, the selection of certain extended verbs (notably V82, V83, V85, V90) or other DSKY activity may result in a software restart and extended verb activity is lost. Recovery procedure: reselect extended verb.

2.1.13(BC) In V82 and V89 the correct values to be loaded into R2 of N12 for the option code are 1 and 2. Any other value will be treated as a 2.

2.1.14(BC) RTHETA displayed in R3 of N54 (V83) may be incorrect for one display cycle and, therefore, care should be taken when freezing the DSKY to insure that RTHETA was valid when the DSKY is frozen. This problem exists because the cell that is displayed as RTHETA is used to contain an intermediate value in the computation of RTHETA and, therefore, if the display should update while RTHETA contains this intermediate value the DSKY would contain the wrong number. The DSKY should not display an intermediate computation for more than one display cycle (1 second) as there is no correlation between the N54 computation cycle and the display update cycle.

2.1.15(B) If V89 is attempted during P00 with no valid REFSMMAT, a program alarm 220 and a FLV37 will result. If the IMU is off, a 210 program alarm and a FLV37 will result. Any attempt to select another extended verb with displays at this time will result in an Operator Error. The FLV37 should be responded to by keying 00E before further keyboard activity.

* 2.1.16(BC) V96 destroying W-matrix - See Program Note 2.5.9.

2.1.17(BC) During burn programs (except P41 and P47), astronaut use of the DSKY will mask possible V97 display (thrust fail display). Avoidance: Do not allow extended verb, monitor, or static displays to occupy DSKY for long periods of time during thrusting.

* 2.1.18(B) If an extended verb has been selected on top of a normal display during a mission program, 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.

* 2.1.19(B) The following functions are not restart (i.e., hardware or software) protected.

a. Astronaut initiated verb/nouns
Recovery procedure: reselect verb/noun

b. Extended verbs
Recovery procedure: reselect extended verb

c. Automatic attitude maneuvers (except those called by P20)
Recovery procedure: PRO to FLV50N18 that returns to DSKY after restart. If V49 or V89 maneuver, reselect extended verb.

d. Coarse align and gyro torquing
Recovery procedure: alignment is lost, perform P51 and/or P52 or emergency alignment procedure.

2.1.20(B) When loading decimal data into the AGC, the ENTER sometimes changes the last digit of the loaded value since PINBALL round-off in decimal/octal/decimal conversions occurs when data is keyed in (decimal to octal) and entered and redisplayed (octal to decimal). Data shown on the DSKY can be displayed as modulo the maximum value allowed or can be data from a previous calculation that was stored into the cells picked up for display. The crew is encouraged to always write over data with the desired information.

2.1.21(BC) There are 7 priority displays in LUMINARY which will ignore any response for 2 seconds:

V06N49 in R22
V50N18 in P20 or P25
V50N72 in P20
V05N09 in P20 (Alarm codes 501, 503, 514, 525)
V06N05 in P20, P22
V16N80 in P20
V05N09 in P22 (Alarm codes 503, 514, 525, 530)
The PRIO DISP LT is turned on by all priority displays.

2.1.22(B) 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.

2.1.23(BC) Blank major mode lights indicate that a fresh start has been performed.

2.1.24(BC) Any program can be terminated:

a. Via V34E at any flashing display except the flashing N64 in P64, N60 in P66, N49 of P20 and P22, the flashing N88 in P51, P52, or P57, or V50N25 in P06 (V34E response to an extended verb display will terminate the extended verb and not the program running underneath).

b. Via V37EXXE at any flashing or non-flashing display except with XX not equal to zero for V50N25 in P06.

* 2.1.25(BC) The following program sequences may cause problems:

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

b. P70/71 - P12 - See Program Note 2.4.7.

* 2.1.26 If P20 is selected in the update mode prior to completion of P66, the W-matrix initialization will destroy the E-memory descent targets.

* 2.1.27 Exiting P63, P40 or P42 with a V37EXXE approximately 1.7 milliseconds before ullage on will result in ullage coming on and not being terminated, with Average-G integration not running. The mission effect is a degraded state vector since ullage is on and average-G is not on. Avoidance: Key V37EXXE prior to TIG-10 seconds. Recovery procedure: If avoidance not possible, key V37EXXE after ullage comes on. See also Anomaly Report L-1E-02 Rev. 1.

2.1.28(BC) If a V37EXXE is attempted within approximately 15 seconds of a fresh start or ISS turn on, a PIPA FAIL will go undetected. Recognition: None by the crew, ground support will see IMODES bit set. Recovery procedure: Select P00. Then reset IMODES30 bit 5 via V25N07E, 1277E, 20E, E. See also Program Note 2.2.4.

2.1.29(B) The program will ignore any direct 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.

2.1.30(BC) Downrupts may be lost at infrequent intervals during high level computer activity.

2.1.31(BC) The TFF display in V82 may be incorrect if the return trajectory is hyperbolic. Recognition: N91 in P21, R2 > 36339 fps.

2.1.32(BC) V82E will result in computational difficulties in translunar and transearth coast because conic integration is used. Not only will V82 produce meaningless results, but in the following specific instances, a 21302 (negative square root) P00D00 abort:

a. In earth sphere when the position vector is greater than 4333NM (TEI + 1.3 hours).

b. In lunar sphere when the position vector is greater than 7743NM (LOI - 3 hours).

2.1.33(BC) Any extended verb display (e.g., N54 in R31 or N44 in R30) will prevent normal displays from coming up until the extended verb display is terminated. For example, the flashing V50N25 in P20 requesting RR Auto Mode Selection will not appear while N54 is being displayed by R31. Only priority displays will preempt the DSKY when an extended verb display is up.

2.1.34(BC) Since program alarms are frequently referenced in this document, this program note will merely attempt to clarify the program alarm structure.

Any time a program alarm is generated, the octal code identifying the alarm is stored in the FAILREGS (which can be displayed on the DSKY via V05N09) in the following manner:

If FAILREG+0 = 0 - Store the code in FAILREG+0 and FAILREG+2.
If FAILREG+0 ≠ 0 and FAILREG+1 = 0 - Store the code in FAILREG+1 and FAILREG+2.
If FAILREG+0 ≠ 0 and FAILREG+1 ≠ 0 - Store the code in FAILREG+2.

In other words, FAILREG+0 contains the first alarm after an ERR RSET, FAILREG+1 the second, and FAILREG+2 always contains the latest.

After loading the FAILREGS, the program illuminates the program caution light on the DSKY. Depression of the ERR RSET Key on the DSKY turns off the program caution light and zeros FAILREG+0 and FAILREG+1, FAILREG+2 maintains the most recent alarm.

There are six types of alarms differentiated by the corrective action that the program takes when an alarm is detected:

LIGHT - This type alarm illuminates the PROG CAUT LIGHT and stores the code in the FAILREGS.

DISPLAY - An alarm of this type does all the functions of "LIGHT" plus the code is automatically displayed on the DSKY (via V05N09), hence an Astro response is required for program continuation.

PRIORITY - An alarm of this type does all the functions of "DISPLAY" except with a priority display (i.e., interrupts any other display except those that are Astro-initiated). See Program Note 2.1.21.

BAILOUT - This type alarm does all the functions of "LIGHT" plus initiating a BAILOUT; i.e., a software restart. The BAILOUT routine terminates the present computer activity and restarts it again using a prestored initialization point. All program alarms of this type have a code in the form of 3XXXX.

POODOO - Alarms of this type do all the functions of "LIGHT" and then does either a "BAILOUT" or a "POODOO." If an extended verb is active, an alarm of this type behaves like a "BAILOUT" (note: the "BAILOUT" would clear any extended verb).

If no extended verb is running, the "POODOO' routine is executed. If AVERAGE-G is not running, the "POODOO routine terminates all current computer activity and inserts a flashing V37 in the verb

register, so that the Astro may reselect a program with a minimum number of key strokes. If AVERAGE-G is running, the "POODOO" routine inserts a flashing V37 in the verb register and terminates all current computer activity except the AVERAGE-G routine and the Abort Monitor routine when in descent or aborts. Therefore, a "POODOO" during a burn program terminates all guidance but allows the State Vector to be updated and abort programs to be entered during descent or P70.

1107 - Alarm 01107 is the only program alarm of this type. This alarm is produced when the LGC assumes the erasable memory has been destroyed. As a result, all of the functions of "LIGHT" are performed plus a "fresh start" is initiated. A "fresh start" initializes certain parts of erasable memory to pre-programed values and leaves the LGC in "negative P00" (i.e., no program and a blank program register).

2.2 IMU, Optics, and Radars

2.2.1(BC) If the PGNS mode control 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.

2.2.2(B) If the IMU is on and in the Coarse Align mode when the AGC is put into STANDBY, the IMU will become inertial, and will return to the Coarse Align Mode after coming out of STANDBY. The NO ATT Light will remain on during the STANDBY period, however. If the IMU were coarse aligned because of Gimbal Lock, going to STANDBY could damage the IMU.

2.2.3(BC) A hardware restart during small windows in T4RUPT may leave garbage in certain bits of IMODES30, IMODES33, and DSPTAB+11D. A restart during V35 may leave garbage in DSPTAB+11D. The effect of incorrect bits settings is summarized as follows:

IMODES30 Bits 1, 3, 4, 5	Incorrect ISS warning indication or incorrect inhibition of true ISS warning.
IMODES30 Bit 9	Erroneous IMU turn-on sequence with associated caging of ISS.
IMODES33 Bit 5	Incorrect indication of IMU zeroing on downlink and prevention of executing V37E.
DSPTAB+11D Bit 4	Erroneous IMU moding into or out of Coarse Align.
DSPTAB+11D Bit 6	No effect.
DSPTAB+11D Bit 9	Erroneous change to program alarm light.

*2.2.4(BC) There are some abnormal consequences of restarts during IMU mode switching.

If a restart occurs (due to POODOO, BAILOUT, V37, or hardware cause) during certain portions of IMU 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. Coarse align to fine align (including V42)
IMUFAIL inhibit which was set during coarse align, is not removed for about 5.12 seconds.

b. IMU CDU zero (V40N20E and at end of V47E)

ICDUFAIL and IMUFAIL are inhibited at start, and the inhibit is not removed for about 10.56 seconds. Bit 6 of IMODES33 is left set, disabling the DAP. V37EXXE is locked out during this 10.56-second period.

A IMU CDU zero during AVERAGE-G will likely cause a 31210 software restart which will, in turn, disable the DAP. Recovery: Reset bit 6 of IMODES33 - V25N07E, 1300E, 40E, E.

c. 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 10.24 seconds and the PIPAFAIL inhibit is not removed for about 14.24 seconds. A V37EXXE is locked out for 10.24 seconds after IMU turn-on sequence completed.

d. 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 10.56 seconds and the PIPAFAIL inhibit is not removed for about 14.56 seconds. A V37EXXE is locked out for 10.24 seconds after the computer comes out of standby.

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.

2.2.5 If a V37EXXE, abort button, or abort stage button is used or if a software or hardware 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 procedure: ERROR RESET and continue.

*2.2.6 A RR turn-on immediately before selecting P20, P22, or V41N72, may cause erratic behavior. Avoidance: Wait 12 seconds after RR LGC mode before selecting P20/P22 of V41N72. Recovery procedure: Cycle RR MODE Switch from LGC-to-SLEW-to LGC. See also Anomaly Report L-1D-22.

2.2.7 Proper values to load in N12 for R04 (V63) are 1 for RR option and 2 for LR option. A 0 or negative number will be treated as a 1 and any number >2 will be treated as a 2.

2.2.8 Proper values to load in N12 for V41N72E are 1 for Lock-on option and 2 for Continuous Designate option. Values which will give the Lock-on option are 0, 1, 4, 5, ---. Values which will give the Continuous Designate option are 2, 3, 6, 7, ----.

*2.2.9 A restart during R04 (V63) will cause subsequent selection of R77 (V78) to result in OPERATOR ERROR unless a major mode change (V37) has been performed. See also Anomaly Report L-1E-12.

2.2.10 The LR Slant Range/Altitude displayed in N66 of R04 will not be valid for approximately 4 seconds after N66 first appears on the DSKY. The N66 appears immediately after the PRO on the N12 option code, the LR sampling is started 0.6 second later. The LR sampling is done one parameter per second in this sequence:

LR Vel X
LR Vel Y
LR Vel Z
LR Altitude

2.3 DAP

* 2.3.1 In order to avoid excitation of the CSM-docked bending mode and possible damage to the docking tunnel, rapid pulsing of the ACA should be avoided in the ATT HOLD/rate command mode. Recognition: Perceiving a surprising increase in RCS jet activity and seeing a sinusoidal motion on the FDAI error needles (between 2 and 4cps).

*2.3.2 For a certain range of fuel loading in the CSM-docked configuration each of the LM + X thrusting jets produce a torque opposite in direction to its normal sense due to impingement on the RCS jet plume deflectors. In this range, firing these jets is a waste of fuel, and, furthermore, a disabled or failed off -X thrusting jet will cause instability in the CSM-docked control during coasting flight. Avoidance: Disable all deflected (+X thrusting) jets when the c.g. is above STA 364 and disable jet 6 (jet 3D) when the c.g. is above STA 302.5.

2.3.3 When a light LM is docked to a heavy CSM the torque from the jet 6 (3D) plume deflector is sufficient to overpower the torque from both jets in that pair, so that the net torque from a two-jet firing is in the wrong direction and control will be unstable. Jet 6 must be disabled during LM PGNCS coasting flight control of the docked vehicles when the c.g. is above STA 432.

* 2.3.4 If the DAP is used for a backup CSM-docked DPS burn:

a. SNUFFER bit should be set (Verb 65) to inhibit U and V jet firings during the burn.

b. 40 percent throttle should be manually commanded from TIG+5 seconds until full throttle is automatically commanded to reduce the size of throttle-up transients.

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

2.3.6(BC) Depending upon initial gimbal angles, the VECPOINT routine may result in large computated 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 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.

2.3.7 With the DAP deadband of 0.3° and a phase plane logic containing a "flat" of 0.8°, the DAP does nothing to correct an attitude error of up 1.1° providing it computes that the yaw rate error, however slight, is such as to diminish the yaw error. There are several ways, too elaborate to describe here, in which the

yaw error can be produced. The resolution of FINDCDUW's rate commands is much finer than the resolution of the angle commands, which in many cases causes the DAP to erroneously compute that the yaw rate error is such as to diminish the yaw error; consequently, the DAP does nothing and the error persists.

* 2.3.8 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.

2.3.9 Due to the thrust direction during ullage not passing through the center of gravity the IM will move toward the deadband, possibly exceeding it, and the attitude at ignition is wrong. A restart during ullage will cause the desired CDU's to be equal to the actual CDU's and the center of the deadband is redefined. So, one Restart during ullage may double the attitude error at ignition.

* 2.3.10 If the discrete from the GUID CONT switch (PGNCS or AGS) fails such that the indicated mode is AGS control even though PGNCS is still in control, attitude maneuvers in P20, P40, P41, P42, P63, V49, V89, P25, P52, and P99 must be performed manually. NOUN 18 ball angles are computed in each of the above instances.

* 2.3.11 If the PGNCS/AGS indication (channel 30/bit 10) fails in either state and the control is, at some time, actually switched from AGS to PGNCS the switch will not be visible to the DAP and it will not reinitialize its estimates of angular rate and (in powered flight) angular acceleration, which become distorted when the AGS is in control. There is likely to be a noticeable transient in the attitude under the conditions unless the DAP is forced to reinitialize by means of a restart (V69) or a (momentary) switch to the OFF mode.

* 2.3.12(BC) V40N20E disabling DAP - See Program Note 2.2.4.

* 2.3.13 The "NO DAP" light on the DSKY is lit in the idling mode (i.e., MODE CONT off) and the minimum impulse mode. In addition:

a. It is not lit as a result of AGS selection.

b. It is lit after P68 entered if ATT HOLD selected, because P68 does an internal V76E.

c. Unexpected illumination indicates failure in PGNCS mode control switch which is causing the DAP to idle; the other mode is probably available.

d. It is flashed on then off by a hardware or software restart (but not V37EXXE, except for XX = to 70 or 71).

*2.3.14 Do not load a zero or negative number in R1 or R2 of N48 (DPS pitch or roll trim) (SDN-124). Recognition: 21204 alarm. Recovery procedure: Recall R03.

2.4 P12, P70, P71

* 2.4.1 The cross range displayed in N76 of P12 is the size of the lateral maneuver which the guidance intends to make during ascent. It is not the distance out of plane of the injection point. The initial N76 display is based on coplanar injection, that is the guidance intends to remove all the out-of-plane. If the crew overrides this value via the keyboard, a noncoplanar insertion will result. Cross range should not be specified such as to cause the ascent trajectory to cross through the CSM orbital plane.

2.4.2 During the vertical rise portion of ascent, Vgx in N94 will display something like +900.0fps. This is because the $\underline{V}g$ includes compensation for the expected ΔV due to gravity, and during vertical rise this is all along the X axis. At pitchover, this should increase to about 4800.0fps.

2.4.3 The delta velocity (DV) measured during powered flight may be in error up to 20fps at the beginning of an Ascent (P12), and remains throughout the Ascent. There is no mission effect since the DV is only on the downlink, R3 of N40, R3 of N62, and is not used for guidance or navigation. For the same reason that DV is incorrect, the vehicle mass would also be slightly in error.

*2.4.4 Drift of $\underline{V}g$ after Insertion - The radial velocity target and the downrange target in the case of P12 are fixed. Therefore, when the vehicle is in a non-circular orbit and its actual radial and tangential speeds vary after insertion, the residuals ($\underline{V}g$) displayed in N85 will change. The horizontal drift is mainly a function of radial rate and for nominal insertion it is .031 ft/sec^2. (For aborts, there is no drift.) The radial drift is mainly a function of insertion speed. It varies essentially linearly from .045 ft/sec^2 for V = 5500fps to .315 ft/sec^2 for V = 5640fps. The numbers quoted are the changes in the actual vehicle rates. For body X-axis horizontal and wings level, they will be Vgx and Vgz, respectively.

2.4.5 The rotation control logic built into the guidance for abort situations will work in all reasonable situations. However, it is possible to get into conditions where rotation through the downward vertical happens. Consider, for example, a very early abort in which a manual pitch maneuver over-the-top is made giving a significant (upward) radial rate, and an over speed down range rate. If Tgo<10 when P70/71 is entered, the desired thrust vector, with position control off, will be downward and retrograde. If the vehicle X-axis is within 30° of +R, rotation control is off, and if the angles work out right the vehicle could pitch forward through the downward vertical.

Other possibilities could be outlined, but it should be pointed out that they all require very unusual combinations of state vector and vehicle attitude. Pitch through the downward vertical is not impossible, just highly unlikely.

*2.4.6 If an engine fail occurs in P70 or P71, and a ENTER response is made to the flashing V97, NOUN 63 will be displayed with the flashing V99, instead of NOUN 94. NOUN 94 will be restored when the V99 display is answered. Also see Anomaly Report L-1E-05.

*2.4.7 If P70 or P71 is attempted after touchdown but liftoff is not allowed, the subsequent P12 to launch into orbit will be targetted for and guided with Variable Insertion Targeting equations. The orbit will be a safe orbit, but the phasing with the CSM will be that which was set up earlier by the P70 or P71 attempt. Recognition: Insertion velocity in NOUN 76 display. Avoidance: Reset flag set in P70 or P71 (P7071FLG).

V25N07E
105E
10000E
E

Recovery: None necessary. Also see Anomaly Report L-1D-24.

2.4.8 DSKY use masking V97/V99 - See Program Note 2.1.17.

* 2.4.9 A V97 (engine-failure) during P12, P70, and P71 may cause the engine to shut down prematurely or late. This is caused by a software interlock between V97, the ascent guidance engine-off control logic, and conflict in use of TTGO cell between CLOCKJOB and the ascent guidance equations. If a V97 is being displayed as a consequence of a momentary drop in thrust during ascent, key PROCEED promptly and be prepared to manually turn off the engine or trim the residuals if shutdown is early. The problem exists only if the time-to-cutoff is computed to be less than 4 seconds when the PROCEED is keyed. See also Program Note 2.1.17. See also Anomaly Report L-1E-09.

2.4.10 V97/V99 with V06 appearing. See Program Note 2.7.3.

2.4.11 The altitude reference for abort targeting and displays will be RLS as modified by any N69's which were loaded prior to or during descent.

2.5 Rendezvous

2.5.1(BC) P20 rendezvous navigation provides a priority display (V06N49) of ΔR and ΔV when the state vector update exceeds the padloaded erasable values RMAX or 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 $\Delta V < 0.006$ meters/second for earth or <0.0015 meters/second for moon.

2.5.2(BC) The range and range rate display in V83 may degrade considerably at ranges less than 0.3 to 0.5NM depending on navigation accuracy.

2.5.3 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: If desired, key terminate (V34E) in response to a N49 display from the trunnion angle measurement.

2.5.4(BC) If V56E or V34E on a P20 display (excepting N49) is keyed to terminate P20 during a computation in P32, P33, P34, P35, P72, P73, P74, or P75, these computations will be restarted from the beginning.

2.5.5(B) The assumption is made in P34/P74 that the resultant perigee altitude will be less than 9999.7NM. If it is greater, then the N58 R1 display will become meaningless.

*2.5.6 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 procedure: Attitude maneuver (V50N18) will break lock, position the +Z axis along LOS, and RR will be designated to Mode I.

2.5.7 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 procedure: Self recovery.

* 2.5.8 Do not key a PRO response to the V16N80 display in R24, automatic search routine, in P20 unless R1 = 11111, indicating RR lockon achieved. Recovery procedure: Reselect P20 and redo R24. A PRO response with R1 = 00000 results in the program getting hung up in an RR designate loop which will never terminate. See also Anomaly Report L-1E-07.

* 2.5.9(BC) A V96E can cause the W-matrix to be out of phase with the state vectors if it is performed: (a) during P20 mark processing, but only if the CSM state is being updated (V81); or (b) 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 procedure: For (a) none needed; (b) V93E.

2.5.10(BC) There are no known problems although due to a lack of verification testing, the rendezvous programs should not be operated in the earth sphere.

* 2.5.11(BC) If P32/P72 is terminated prematurely because of a program alarm, for example, it is not possible to execute P33/P73 using normal procedures. Unless P32/P72 is completed to the extent of PROing on N82, TPI time, a required input to P33/P73 is not stored in the register used by P33/P73 (TTPIO). P33/P73 at initialization takes the value stored in TTPIO and stores it in TTPI, the register from which N37 is displayed. Therefore, it is possible using the following procedure to recover and execute P33/P73.

At the first V16N45 display in P33/P73, Key V25N37E and load the nominal TPI time.

In addition if P32/P72 was not executed at all or if the alarm occurred because of a bad elevation angle it is necessary to Key V22N55E and load the nominal elevation angle.

P33/P73 will then have all its required inputs available.

2.5.12(B) Lambert computations should not be used within 3 degrees of a target vector.

2.5.13 If the elevation angle option is loaded in P34 and time of ignition computed for a direct rendezvous, a 611 alarm (no TIG for this elevation angle) may occur. This is not a problem for Apollo 16 or 17 as the timeline calls for loading TIG and computing elevation angle.

* 2.5.14 If (a) P3X (or P7X) is performing computations; i.e., first PRO or RECYCLE response to V16N45, (b) P20 loses lockon and is doing R21 to reacquire (this is caused by a hardware restart, by R25 finding RR angles out of limits, or by loss of RR data good), and (c) a restart occurs during the permanent state vector integration done by P20 just prior to calling R21, abnormal program behavior results as follows.

a. P32/72 - 31502 Bailout and backward integration.

b. P33/73 - Indeterminate transfer and possible hardware restart.

c. P34/74 - TIG Option-Backward integration; elevation option-611 alarm plus 31502 Bailout alarm.

d. P35/75 - Indeterminate transfer and possible hardware restart.

Recovery procedure:

a. P32/72 - V96 to kill integration, then reselect P32/P72 and P20.

b. P33/73 - V37E00E to terminate P20 and P33/P73, then perform General Systems Checkout (Flight Crew G&N Dictionary) then continue.

c. P34/74 - Same as P32/72.

d. P35/75 - Same as P33/73.

See also Anomaly Report L-1E-10.

* 2.5.15 A restart during P20 or P22 when a FL V37 is on the DSKY due to R02 finding REFSMFLG reset results in a continuous 31502 program alarm being generated. The continuous Bailout alarm locks out the DSKY making it necessary to simultaneously depress the MRK REJ and ERR RESET buttons to cause a FRESH START. See also Anomaly Report L-1E-11.

2.5.16(BC) The display of out-of-limits state vector updates in the LGC (N49) by P20 navigation routines involves a high priority (27) tight loop which waits for responses to the display. The effect is that all other P20 activities (specifically further marking and tracking) cease until a response to the display is received.

2.6 P21-P30

2.6.1(BC) In P21, the correct values to be loaded into R2 of N06 for the option code are 1 and 2. Any other value will be treated as a 2, except +1, 0, and -1 will be treated as a 1.

*2.6.2 If Range to CSM is >400NM and range rate is negative when P22 is selected, V37 will not flash when Range to CSM>400NM and range rate is positive (after CSM passes over). Avoidance: Select P22 when Range <400NM. Recovery procedure: V37E00E when NO TRACK light comes on. It is recommended that the recovery be used rather than trying to avoid the problem. See also Anomaly Report L-1E-01.

*2.6.3 When P22 is selected the W-matrix is initialized, regardless of the state of RENDWFLG (making V93E ineffective). There is no mission effect since P22 is not used for navigation. See also Anomaly Report L-1E-04.

2.6.4(BC) 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.

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

2.6.6(B) 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.

2.6.7 Restart during P22 with REFSMFLG reset. See Program Note 2.5.15.

2.7 P4X

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.

2.7.2 In P40/P42, at the V99 request to enable ignition, an ENTER response before TIG-0 followed by a restart will blank the DSKY. Average-G is still going and NOUN 40 may be monitored. If a PROCEED to V16N40 had occurred before the Restart and TIG-0, NOUN 85 is callable. To exit P40/P42, V37EXXE may be used.

2.7.3(BC) During thrusting programs when V99 or V97 is flashing, V06 may occasionally appear for one flash. This happens because V97 and V99 are paste verbs. There is no recovery procedure required.

2.7.4(B) The TGO display in N40 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.

2.7.5(B) The $\underline{V}_G$ or $\Delta\underline{V}$ displays in body axes, 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 - 1 1/2-second delay between the application of ΔV and the visible result.

2.7.6(BC) DSKY use masking V97 - See Program Note 2.1.17.

2.7.7(B) 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.

2.8 P5X

2.8.1 There is an approximation error in the LGC computed unit vectors for the Earth and Moon, especially when marking on the Earth within the Moon's sphere of influence or the Moon within the Earth's sphere. Marking on the Sun is only degraded at the edge of the Earth's sphere of influence. Avoidance: If the Sun, Moon, Earth options are to be used in the LGC for an alignment, the ground should provide the unit vectors.

*2.8.2 With a failed on ROD switch MARK REJECT is inhibited.

2.8.3(BC) In P52 and P57, 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.

2.8.4 P52 using the cursor/spiral technique will not operate if the IMU is misaligned by greater than approximately 3° in any one axis. The cursor/spiral technique uses an iterative process, which if it fails to converge will reject the mark. The iteration process may fail to converge for a particular mark if any axis of the platform is misaligned by greater than 3°, the sighting is made on the wrong star, or if the measured cursor/spiral is incorrectly loaded. A mark will also be rejected if the star is within 2° of the AOT optic axis or if the star lies on the edge of the AOT field-of-view greater than 28.5° from the optics axis. If a mark is rejected by the program for any reason the program will display checklist code 16 (FL V50 N25 R1 = 16) with the number of rejected mark sets in R2.

P57 uses the same mark processing routines as P52 cursor/spiral, however, the iteration process uses a different initialization point which makes the iteration process insensitive to platform misalignments and incorrectly identified stars.

*2.8.5(BC) Sightings on two celestial bodies provide 4 degrees of freedom and only 3 are needed in the alignment programs. The programs are designed to use 2 degrees of freedom provided by the first celestial body and use only the azimuth of the second body (about the line of sight to the first body) for the third degree of freedom. Thus, the first target sightings should be on the most accurately known source. For the LGC the hierarchy of optical targets is: stars, sun, planets, and earth/moon. See also Program Note 2.8.1.

2.9 P6X

2.9.1 In P66 there is a possibility, depending on execution time, that the information telemetered in the TRUDEIH cell would be a velocity cell (DELVROD) instead of the true DELTA H. The P66 entrance disables the terrain model and the "post-model" (i.e., DELTA H) cell could be used to construct the desired data. There is no mission effect since the problem exists only for telemetry.

* 2.9.2 DSKY use masking V97 - See Program Note 2.1.17.

2.9.3 V97/V99 with V06 appearing - See Program Note 2.7.3.

*2.9.4 Going directly from P63 to P66 causes P66 to use the P63 value for the landing radar altitude measurements weighting factor instead of the value initialized at the start of P64. See also Anomaly Report L-1D-13.

*2.9.5 A V34E response to the flashing V06N60 display in P66 will result in a 31502 Bailout alarm. The V34E selects R00 which tries to flash V37, however, the next pass of P66 attempts to redisplay V06N60. The Bailout alarm removes the FLV37 and V06N60 is redisplayed. See also Anomaly Report L-1E-03.

2.9.6 Because the LM throttle is controlled in a closed loop fashion; i.e., accelerometer data rather than a history of pulse outputs is used to tell where the throttle currently is - a transient thrust failure may cause throttle pulses to be issued by the LGC which will result in a thrust level in the forbidden region when the engine comes back on. This condition will correct itself on the next pass.

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