Addressees:
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CFK/F. Hughes
MIT/SDL/D. Hoag
P. Felleman
S. Copps (3)
J. Nevins (3)
R. Larson (3)
K. Greene (3)
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MIT/KSC/R. O'Donnell
R. Gilbert
NAA(Downey)/L. Hogan
J. Potts
B. Schoen, DA35 (3)
E. Woosley
GAEC(Houston)/D. Massey
C. Tillman (5)
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R. N. Harris
D. Hardin
LINK/A. Dahlberg
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M. Meyers
AB/C. C. Kraft, Jr.
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A. Bean
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F. M. Haise
D. R. Scott
R. L. Schweickart
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J. Carr
T. Mattingly
S. Roosa
V. D. Brand
H. H. Schmitt
CF/W. J. North
CF2/M. E. Dement
CF22/C. C. Thomas
D. L. Bentley
J. J. Monroe
CF4/P. C. Kramer
CF42/A. G. Nolting
CF7/H. A. Kuehnel
CF75/J. J. Van Bockel
T. Putnam (MAC)
CF8/S. Faber
E. B. Pippert
EA/M. A. Faget
EA2/R. A. Gardiner
ED3/M. T. Cunningham
S. M. Keathley
J. L. Raney
EG/MIT/T. Lawton
EG/C. W. Frasier
EG2/D. C. Cheatham
C. Hackler
EG23/K. J. Cox
EG24/J. W. Van Artsdalen
EG27/D. W. Gilbert
R. Reid
H. G. Patterson
EG41/J. F. Hanaway
HA/J. L. Tomberlin
KM/F. C. Littleton
PA/G. M. Low
PD/A. Cohen
O. E. Maynard
R. J. Ward
R. V. Battey
PD8/W. B. Goeckler
PE7/D. T. Lockard
PT2/K. L. Thomas
TE/B. G. Jackson
FA/S. A. Sjoberg
H. W. Tindall, Jr.
FC/E. F. Kranz
G. S. Lunney
J. S. Llewellyn
J. C. Bostick
A. D. Aldrich
G. D. Griffin
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C. B. Parker (5)
J. W. Roach
R. A. Hoover
C. B. Shelley
W. E. Fenner
S. G. Bales
K. W. Russell
FC/W. Presley
G. Renick
G. Paules
FM/J. P. Mayer
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FM2/F. V. Bennett
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R. T. Savely
FM5/R. L. Berry
FM6/E. C. Lineberry
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R. W. Cole
FS4/A. D. McLaughlin
FS6/J. A. Miller
FS5/J. C. Stokes, Jr.
T. F. Gibson, Jr.
L. J. Dungan
J. R. Garman
J. W. Jurgensen
C. D. Sykes
G. R. Sabionski (3)
J. A. Martin
T. G. Price (5)
TRW(Redondo)/M. Elowitz
LEC/W. Warrenburg
CB/E. Gibson

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

IN REPLY REFER TO: 70-FS55-34

1970

MEMORANDUM TO: See list attached

FROM : FS/Chief, Flight Support Division

SUBJECT : COLOSSUS 2D and LUMINARY 1C program and operational notes, first edition for mission H_2 (COMANCHE 72 rev. 3 and LM131 rev. 1)

1. Enclosed is the present version of all known COLOSSUS and LUMINARY program and operational notes for the H_2 mission. These notes are divided into four sections. Section A covers all COLOSSUS program and operational notes and section B, all LUMINARY program and operational notes. Sections C and D cover COLOSSUS notes and LUMINARY notes, respectively, that are applicable to any present or future release of those programs. A description of the numbering convention is also included.

2. Any questions should be directed to the COLOSSUS Program Engineer, Mr. G. R. Sabionski, or the LUMINARY Program Engineer, Mr. T. G. Price, both at extension 6247.

Arnwood C. Dunseith

Enclosure

FS55:GRSabionski:jvm

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

A. First digit

1 = Crew notes and checklist items - These are notes being of particular interest to the crew.

2 = Ground notes - These are notes being of particular interest to mission operational and planning people.

3 = Restarts and priorities

B. Second digit

1 = Nouns, verbs, displays

2 = Selection of new programs and extended verbs

3 = Ground updates and pad loads

4 = Navigation and W-matrix

5 = Rendezvous and targeting

6 = Optics, IMU, and radars

7 = Guidance and control, boost, and entry

C. Last digit, order number

ENCLOSURE

Section A

Program and procedure notes applicable to the H2 mission.

1. Crew Notes and Checklist Items

1.1 Nouns, Verbs, and Displays

1.1.1 Some nouns are not manually callable with valid data at any time, e.g., 5, 6, 7, 12, 16, 24, 25, 26, 29, 30, 31, 34, 41, 72, 97, 98.

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

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

V06N49 in R22
V05N09 in R52
V50N18 in R60 during P20

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

Section A

1.2 Selection of New Programs and Extended Verbs

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

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

a) IMU mode switching
   1. Coarse align to fine align (including V42)
      IMUFAIL inhibit which was set during coarse align, is not removed for about 5.12 seconds.
   2. IMU CDU zero (V40)
      ICDUFAIL and IMUFAIL are inhibited at start, and the inhibit is not removed for about 10.56 seconds.
   3. IMU turn-on
      After the 90-second turn on sequence is completed (No ATT lamp on)
      the IMUFAIL, ICDUFAIL and PIPAFAIL are all inhibited. The IMUFAIL and ICDUFAIL inhibits are not reset for about 10.24 seconds and the PIPAFAIL inhibit is not removed for about 14.24 seconds.
   4. Computer out of standby with IMU on
      IMUFAIL, ICDUFAIL, and PIPAFAIL inhibits are set at start. The IMUFAIL and ICDUFAIL inhibits are not reset for about 10.56 seconds and the PIPAFAIL inhibit is not removed for about 14.56 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.

b) Optics Mode Switching
   1. Optics Zero
      After the optics have been in zero for 33 cycles of T4RUPT (15.84-16.32 seconds) the OCDUFAIL inhibit is left on for an additional .4 seconds. Recovery

Procedure: First clear bit 1 of OPTMODES as follows: V25N07E, 1331E, 1E, E, then repeat OPTICS ZERO.

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

Section A

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

1.2.4 The following program sequences will cause problems:

a) P3X - P7X - P40 or P41
P3X - P17 - P40 or P41
P3X - P23 - P40 or P41
Problem: P3X computations are overwritten. Recovery procedure: Redo P3X and then P40 or P41.

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

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

1.2.6 Depending upon initial gimbal angles, the VECPOINT routine may result in large computed rotations about the pointing vector when the pointing vector must be rotated through about 180° (an example of this would be in P40 or P41. If the +X axis were about 180° away from the thrust vector, the V50N18 may display a large change in outer gimbal angle.) Recovery procedure: If the computed attitude is acceptable then simply proceed with the maneuver. If it is not, then manually maneuver in pitch and have the solution recomputed after some 20-to-30 degrees by keying PRO on V50N18 while not in CMC and AUTO.

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

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

1.2.9 Blank Major Mode lights indicate that a fresh start has been performed except in two cases. A hardware restart (caused by a V69 or a hardware failure) 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.

Section A

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

1.2.11 It is possible to do an unintentional permanent state vector update by doing V82, V89, V90 in P00, possibly resulting in erroneous state vector and W-matrix.

The problem can be avoided by doing V96 before selection of any of these extended verbs while in P00.

P00 may be reselected and after the computer activity light goes off, the extended verb may be selected with the assurance that no attempt to integrate in P00 will be made for 10 minutes.

See also Anomaly Report COM 36.

1.2.12 If V89 is attempted during P00 with no valid REFSMMAT, a program alarm 220 and a V37FL will result. Any attempt to select another extended verb with displays at this time will result in an Operator Error. The V37FL should be responded to by keying 00E before further keyboard activity.

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

1.2.14 Selection of the SATSTICK Routine via V46 following use of the RCS DAP, must be preceeded by reloading the rate constants for SATURN in eras. locs. SATRATE thru SATRATE + 3.

Failure to do this may result in saturated AK's when SATSTICK is re-selected.

1.2.15 If a restart OCCURS during execution of R04 (Saturn TB6 initiation routine) the routine will terminate and a FLV37 will appear on the DSKY. To reinitialize R04 after a restart the entire starting sequence should be repeated, i.e. execution of V96E, loading of N26, execution of V30E. (See COLOSSUS Memo No. 222, Rev 1)

1.2.16 Do not key V30N26E to start R04 (initiate SATURN TB6) after N33 TIG has passed or else one of the following will result:

a) immediate 21204 P00D00 alarm

b) 81.92 second delay with non-usable DSKY and then 21204 P00D00 alarm

Section A

c) TB6 START (uplink activity on) sometime within next 81.92 seconds

If TB6 must be started immediately use NO7 to set injection sequence start (Channel 12 bit 13). See anomaly COM 34.

Section A

1.3 Ground Updates and Pad Loads

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

1.3.2 If a "permanent" state vector integration results in changing origin centers at the end of the integration, the downlink state vector will be zeros, except for time. If this happened and the CMC left in P00, the CSM state vector may remain zero for over 4 hours, but the LM state vector would reappear in 10 minutes.

The downlink CSM states can be re-established by using P23 to cause a permanent update. This can be done by proceeding to the FLV50N25 R1=202 display, keying PRO and then terminating at FLV50N18. The downlist LM state can be re-established by calling P00. See also Anomaly Report COM 35.

Section A

1.4 Navigation and W-matrix

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

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

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

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

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

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

1.4.5 In P37, ΔV solutions of < 5 FPS will bias TIG incorrectly. For an RCS burn of 1 FPS 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.

Section A

1.5 Rendezvous and Targeting

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

1.5.2 P38 Stable Orbit program, operating in mode 1, only computes TFINAL on initial entry of the program. It is not recommended on each recycle or proceed from V16N45. To have TFINAL recomputed, reselect P38.

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

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

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

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

1.5.7 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 - 30 minutes may be experienced.

Section A

1.6 Optics and IMU

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

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

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

Section A

1.7 Guidance and Control, Boost, and Entry

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

1.7.2 During TVC control (in P40), astronaut use of the DSKY will mask possible V97 display (thrust fail display). Avoidance procedure: Do not allow extended verb, monitor or static displays to occupy DSKY for long periods of time during TVC.

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

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

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

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

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

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

Section A

1.7.9 Failure of the SPS ENG ON channel flipflop (C11 B13) in either the "off" or "on" State prevents proper software-controlled SPS ignition and shutdown, and requests timely astronaut intervention for reasonable burn performance. The SPS THRUST switch (DIRECT ON/NORMAL) provides manual override of an off-type failure. The ΔV THRUST A/B switches (NORMAL/OFF) provide manual override of an on-type failure. There is also SCS backup capability.

Control of the SPS hardware ignition/shutdown represents one class of problems associated with on/off-type failures of SPS ENG ON. Another class of problems arises because of internal software checks of SPS ENG ON to control program branching. Three problems deserve special attention. First is a check of SPS ENG ON to enable mass decrementing when the engine is firing. An off-type failure will inhibit mass decrementing, so that if manual override or SCS backup is used to complete the burn, a discrepancy will exist between end-of-burn CSMMASS(N46) and actual vehicle mass. Such discrepancies (some large, some small, depending upon burn duration) are generally associated with either on/off-type SPS ENG ON failure, and require ground update of CSMMASS followed by R03 (V48) for correct mass properties and RCS gains.

The SPS ENG ON check in the V37 logic causes P00 lock-in when SPS ENG ON fails in the "on" state. The recommended workaround requires starting up a job at a point in the V37 logic just below the SPS ENG ON check. The desired program number in octal must be manually loaded, prior to starting the special job via V30N26E. Keystroke activity is as follows, for MANCHE 72 Rev 3 (COLOSSUS 2D):

Set up new program number:

V21N01E
775E MMNUMBER
XXXE PROGRAM NO. in OCTAL

Prepare noun 26 (V37 logic, just below SPS ENG ON check):

V25N26E
30000E PRIORITY 30
2025E ADRES (V37+12D)
10063E BBCON (V37+12D)

Begin execution of V37 logic:

V30N26E

Section A

The SPS ENG ON check in the P40 STEERING logic (non-impulsive burn) causes V06N40 hangup and prevents V16N85 access when SPS ENG ON fails in the "off" state. To avoid this situation do not respond to the flashing V97 when the engine is manually ignited (normally one PROCEEDS to re-establish guidance and V06N40). After burn completion respond to the still flashing V97 with ENTER to get to the flashing V99, and ENTER again to get to the desired V16N85 burn residuals.

Section A

2. Ground Notes

2.1 Nouns, Verbs, and Displays

2.1.1 See 1.1.2.

Section A

2.2 Selection of New Programs and Extended Verbs

2.2.1 See 1.2.1.

Section A

3. Restart Notes

3.1 Nouns, Verbs, and Displays

None

Section A

3.5 Rendezvous and targeting

Section B

Program and procedure notes applicable to the H_2 mission.

1. Crew Notes and Checklist Items

1.1 Nouns, Verbs, and Displays

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

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

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

Section B

1.2 Selection of New Programs and Extended Verbs

1.2.1 The following program sequences may cause problems: 1) P3X-P47-P40, P41, or P42 - The P3X computations may be overwritten. Recovery: Repeat P3X and then P40, P41, or P42.

1.2.2 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 IMODES bit set. Recovery: Select P00. Then reset IMODES 30 bit 5 via V25N07E, 1277E, 20E, E.

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

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

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

1.2.6 Do not select P20 in the update mode prior to completion of P65, P66 or P67. The W-matrix initialization will destroy the E-memory descent targets.

1.2.7 Depending upon initial gimbal angles, the VECPOINT routine may result in large desired rotations about the pointing vector when the pointing vector must be rotated through about 180° (an example of this would be in P40, P41, or P42). If the +X axis were about 180° away from the desired thrust vector, the V50N18 may display a large change in yaw desired. Recovery: If the computer attitude is desired then simply proceed with the maneuver. If it is not, then manually maneuver in pitch and have the solution recomputed after some 20-to-30 degrees by keying PRO on V50N18.

Section B

1.2.8 If V59E is used to reposition the landing radar antenna to position #2 at any time other than powered descent, the return from the repositioning routine will be incorrect and V61 will be executed. Avoidance: Do not use V59E other than during powered descent in P63. Recovery: If in P00, reselect P00.

1.2.9 If V44 (terminate RR continuous designate) is keyed in while an antenna remode is in progress, the RR error counters are disabled which stops the antenna drive. A RR coarse align request (V41N72) during this time can cause erratic antenna behavior. Avoidance: Do not key V44E if RR is known to be remoding. Recognition: Antenna will not designate properly in V41N72. Recovery: V37 select of any program, followed by cycling RR mode switch.

1.2.10 If a V37EXXE is done after ullage initiation and prior to ignition (ullage terminates 0.5 seconds after ignition) in P40, P42, or P63, then AVERAGE-G is terminated immediately but ullage is not terminated until AVETOMID integration is complete causing an incorrect navigated state vector. Avoidance: Use V34E in response to a flashing V99NXX; if engine is on, press engine stop button, then V37EXXE. Recovery: Uplink new state vector.

Section B

1.3 Ground Updates and Pad Loads

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

Section B

1.4 Navigation and W-matrix

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

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

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

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

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

Section B

1.5 Rendezvous and Targeting

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

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

1.5.3 The $\underline{V}g$ or $\underline{\Delta}v$ displays in body axes, N83 or N85, are based on reading the accelerometers every two seconds. The displays, however, are asynchronous one-second monitors. The result is a $\frac{1}{2}$ - $1\frac{1}{2}$ sec. delay between application of ΔV and the visible result.

Section B

1.6 Optics, IMU, and Radars

1.6.1 If the attitude control mode switch is in AUTO or ATT HOLD with rate command/ATT HOLD selected (V77E) during R55 (gyro torguing 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.

Section B

1.7 Guidance and Control, Boost and Entry

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

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

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

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

1.7.5 Do not use V90E (request R36 the rendezvous out-of-plane display) during P12. R36 uses the permanent state (which during ascent would be the $\bar{R}$ and $\bar{V}$ on the lunar surface) and since that state was not an orbital state an acceleration overflow in integration will occur causing a 20430 P00D00 alarm.

1.7.6 Because of the addition of the RCS jet plume deflectors, a disabled -X thrusting jet may cause control instability in the CSM-docked configuration. Avoidance: Disable all deflected (+X thrusting) jets.

1.7.7 Following a restart, ΔV may be subtracted twice from V_G (R2 of N40). This will cause an underburn that is not reflected in the residuals after engine shutdown (L-1C-01). Recovery: Add appropriate ΔV (as determined by ground) manually at end of burn.

1.7.8 The LM windows may be brought up (X-axis override inhibited) at an altitude of 26,000 feet rather than 30,000 feet because of a possible overflow. There is no avoidance and a recovery procedure is not necessary.

Section B

2. Ground Notes

2.1 Nouns, Verbs, and Displays

2.1.1 See 1.1.2

Section B

2.2 Selection of New Programs and Extended Verbs

2.2.1 See 1.2.1

2.2.2 See 1.2.2

Section B

2.3 Ground Updates and Pad Loads

None

Section B

2.4 Navigation and W-Matrix

2.4.1 See 1.4.1

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

Section B

2.5 Rendezvous and Targeting

2.5.1 See 1.5.2

Section B

2.6 Optics, IMU, and Radars

2.6.1 Landing radar incorporation is inhibited at 50 feet altitude (erasable load) by resetting LRINH, Flagword 11 Bit 8. If the LR data good is not present or the reasonability test is not passed, the LRINH bit will not be reset until these conditions are met. There is no mission effect, avoidance, or recovery for this situation.

Section B

2.7 Guidance and Control, Boost, and Entry

2.7.1 See 1.7.1

Section B

3. Restarts and Priorities

3.1 Nouns, Verbs, and Displays

3.1.1 There are seven priority displays in LUMINARY which ignore any response for two seconds:

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

3.1.2 No astronaut initiated verb/noun is restart protected. Recovery: Reselect verb/noun.

Section B

3.2 Selection of New Programs and Extended Verbs

3.2.1 Restart will terminate extended verbs. Recovery: Reselect extended verb.

Section B

3.3 Ground Updates and Pad Loads

None

Section B

3.4 Navigation and W-Matrix

None

Section B

3.5 Rendezvous and Targeting

None

Section B

3.6 Optics, IMU, and Radars

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

Section B

3.7 Guidance and Control, Boost, and Entry

3.7.1 Restarts will terminate automatic attitude maneuvers. Recognition: Restart light or program alarm (software restart) light on with V50N18 flashing. Recovery: PRO to V50N18 that returns to DSKY after restart.

Section C

Program notes applicable to all COLOSSUS releases.

1. Crew Notes and Checklist Items

1.1 Nouns, Verbs, and Displays

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

Section C

1.2 Selection of New Programs and Extended Verbs

1.2.1 In ENTRY (P62-P67), V37's are inhibited after a response to "please perform separation" except a request to perform P00. To call another program, P00 must be entered first, then the desired program called. Care should be taken, however, that P62 be reselected before entering the atmosphere, since AVEG is terminated by going to P00. Of course after separation, GNCS DAP control can only be established by initialization of the entry DAP in P62.

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

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

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

1.2.5 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 7 is treated as 3. as a 6.)
B - D	All odds are treated as 1. All evens are treated as 0.
E	4, 5, 6, 7 are treated as 0, 1, 2, and 3, respectively.

Section C

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

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

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

b) $+30 \text{ DEG} \geq |R2| \geq +0.4 \text{ DEG}$

Section C

1.4 Navigation and W-matrix

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

Section C

1.5 Rendezvous and Targeting

1.5.1 P20 rendezvous navigation provides a priority display (V06N49) of ΔR and ΔV when the state vector update exceeds the pad-loaded erasable values RMAX and VMAX. Currently there are two problems: 1) If the display is desired before every incorporation, any negative value must be set into RMAX, not zeroes; 2) 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. Avoidance procedure: If it is desired to observe V06N49 for each mark then RMAX should be loaded as any negative number. Recovery procedure: None. See also anomaly report COL 21.

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

1.5.3 During rendezvous the orientation of the spacecraft about the track axis is unconstrained, when the rates are updated, approximately every eight seconds, the automatic tracking system does not demand a three-axis solution. This can result in drift around the track axis as follows: 1) for X-axis tracking at $\frac{1}{2}^\circ$ deadband, the maximum drift would be 0.0625°/sec (or 180° in 47 minutes). At 5° deadband, the maximum drift would be 0.5°/sec (or 180° in six minutes); 2) for preferred axis tracking the maximum drift would be 0.0761°/sec (or 180° in 39 minutes) and 0.61°/sec (or 180° in five minutes) for $\frac{1}{2}^\circ$ and 5° deadbands, respectively.

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

1.5.5 In P17 and P77 the correct values for R3 (search option) of N72 are 1 or 2. All other values are treated as a 2.

1.5.6 In R30, P21, P38, P78, R36, and R63 the correct values to be loaded into R2 of N06 or N12 for the option code are 1 and 2. Any other value will be treated as a 2, except P21, R36, P38/78 will treat a +1, 0, and -1 as a 1.

Section C

1.5.7 The assumption is made in the rendezvous targeting routines (i.e., not P30 or P31) that the resultant perigee altitude will be less than 9999.7 NM. If it is greater, then this display (N58) will become meaningless.

1.5.8 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.

Section C

1.6 Optics and IMU

1.6.1 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.

1.6.2 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.

Section C

1.7 Guidance and Control, Boost, and Entry

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

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

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

1.7.4 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).

Section C

2. Ground Notes

2.1 Nouns, Verbs, and Displays

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

2.1.2 See 1.1.1.

Section C

2.2 Selection of New Programs and Extended Verbs

2.2.1 See 1.2.2.

Section C

2.3 Ground Updates and Pad Loads

2.3.1 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.

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

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

Section C

2.4 Navigation and W-matrix

2.4.1 See 1.4.1.

Section C

3. Restart Notes

3.2 Selection of New Programs and Extended Verbs

3.2.1 See 1.2.3.

Section C

3.5 Rendezvous and Targeting

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

Section C

3.6 Optics and IMU

3.6.1 See 1.6.1. Section A.

Section C

3.7 Guidance and Control, Boost, and Entry

None

Section D

Program notes applicable to all LUMINARY releases.

1. Crew notes and Checklist Items

1.1 Noun, Verbs, and Displays

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

1.2 Selection of New Programs and Extended Verbs

1.2.1 Do not select V92 during P00. Recognition: 1) 07 appears in program light; 2) the DAP is turned off for 10 seconds; 3) the W-matrix will be zero or overwritten and if prior to the powered descent would destroy the descent targets; 4) flashing V06N41. Recovery: Select P00 via V37E00E, key V93.

1.2.2 Any program can be terminated: 1) via V34E at any flashing display except the flashing N60 in P65, P66, or P67, or 2) via V37EXXE at any flashing or non-flashing display.

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

1.2.4 Blank major mode lights indicate that a fresh start has been performed except in two cases. A hardware restart (caused by a V69E or a hardware failure) with no restart phases active (no programs to be restarted) will result in a flashing V37 with the major mode lights blank. A V56E to kill P20 will also result in a flashing V37 with major mode lights blanked if P20 was the only program running.

1.3 Ground Updates and Pad Loads

None

1.4 Navigation and W-matrix

None

1.5 Rendezvous and Targeting

None

1.6 Optics, IMU, and Radars

None

Section D

1.7 Guidance and Control, Boost, and Entry

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

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

2. Ground Notes

2.1 Nouns, Verbs, and Displays

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

2.2 Selection of New Programs and Extended Verbs

None

2.3 Ground Updates and Pad Loads

None

2.4 Navigation and W-matrix

None

2.5 Rendezvous and Targeting

None

2.6 Optics, IMU, and Radars

None

2.7 Guidance and Control, Boost, and Entry

None

3. Restarts and Priorities

3.1 Nouns, Verbs, and Displays

None

Section D

3.2 Selection of New Programs and Extended Verbs

None

3.3 Ground Updates and Pad Loads

None

3.4 Navigation and W-matrix

None

3.5 Rendezvous and Targeting

None

3.6 Optics, IMU and Radar

None

3.7 Guidance and Control, Boost, and Entry

None