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LUMINARY Memo #159

TO: Distribution
FROM: R. A. Larson
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SUBJECT: Luminary 1D Program Notes

The attached set of program notes is a first cut for Luminary 1D. These notes are organized in five general categories.

1. GENERAL - Notes that don't fall into the other categories.
2. PROGRAMS
3. ROUTINES
4. VERBS
5. NOUNS

The numbers assigned by FSD in 69-FS55-58 (second edition for mission H_1 notes) are retained for cross reference.

GENERAL

1. 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).

2. 1.2.1 The following program sequences may cause problems: 1) P3X-P47-P40, P41, or P42 - The P3X computations may be over-written. Recovery: Repeat P3X then P40, P41, or P42.

3. 1.2.2 Any program can be terminated: 1) via V34E at any flashing display except the flashing N60 in P66, and N49 in P20 or 2) via V37EXXE at any flashing or non-flashing display.

4. 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.

5. 1.5.2 Lambert computations should not be used within three degrees of a target vector.

6. 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^{o} (an example of this would be in P40, P41, or P42). If the +X axis were about 180^{o} away from the desired thrust vector, the V50N18 may display a large change in yaw desired. Recovery: If the computed attitude is desired then simply proceed with the maneuver. If it is not, then manually maneuver in pitch and have the solution recomputed after some 20-to-30 degrees by keying PRO on V50N18.

6a. If the IMU error counters are enabled when the autopilot is turned on, the FDAI attitude error needles will not be properly initialized. This occurred during Apollo 13 because of the P52 with the DAP off. The recovery procedure is to do a V40N20 with the DAP on.

6b. If the IMU is caged or put into coarse align during pulse torquing, repeated core set overflow alarms may occur (31202 BAILOUT alarms - software restarts). There is a remote chance that this could happen during average-G if the platform goes into gimbal lock. The recovery procedure is to set the erasable GCOMPSW negative - V21 N01 E 1477 E 40000 E.

6c. If a restart (hardware, software, or V37) occurs during IMU moding while the DAP is disabled, the DAP will remain disabled. The major problem is if a V37 is done while a V40 N20 is in progress, the DAP will remain disabled. The avoidance procedure is to wait 15 seconds for the V40 N20 to complete, and the recovery is to repeat the V40 N20.

7. 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 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.

8. 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).

9. 1.7.4 A KALCMANU maneuver rate in excess of 0.5°/sec should not be used in the CSM-docked configuration.

10. 1.7.10 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.

11. 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.

PROGRAMS

P20

12. 1.2.4 If P20 is exited by means of V56E and no other program is running concurrently, the major mode display on the DSKY goes blank and V37 flashes requesting a new program. The integration in P20 is completed but there is no further integration performed until a new program is selected. (LNY-51) Avoidance: Answer the flashing V37 as soon as practical.

13. Do not select P20 prior to PDI because the range read by P20 is stored into the location LRWH1 which is the LR weighting function for P64 and P66, resulting in bad navigation by R12. Recovery: reload LRWH1 by keying V21 N01 E 3756 E XXXXX E.

14. 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.

15. 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.

16. 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.

17. 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. recovery

17a. P25 cannot be used to control vehicle attitude if range to CSM is greater than 566 N. M. Recognition: No attitude maneuvering after P25 is selected.

17b. The following extended verb routines should not be requested if P20 or P22 is running and the range to the CSM is greater than 400 N.M. (P22 displays V 16 N 54 in this case and P20 turns on alarm light, code 526, and stores N54 values for call-up):

R04 (V63) LR/RR Self Test
R05 (V64) S-Band Antenna
R30 (V82) Apogee/Perigee Display
R31 (V83) Range/Range-Rate Display
R47 (V47) AGS Initialization
V67 W-Matrix Monitor
V85 Mode II RR Position Display

This is caused by extended verbs sharing the N54 erasables used by P20/P22.

Recognition: Erroneous displays from extended verbs.

Recovery: Kill extended verbs.

P30

18. 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.

P40

19. 1.7.2 The TGO display in N40 is discontinous immediately after ignition. The ΔV measured becomes fairly constant and the computation settles out in four-to-five seconds.

20. 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.

21. 1.7.1 Do not select P40 or P42 if VG ≤ ΔV_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.

P40

22. If a restart occurs during powered flight, the accumulated velocity may be incremented twice in one Servicer cycle. Recognition: R3 of N40 at end of burn not equal R2 of N40 at start of burn. Recovery: None required.

23. The TPI burn for the short rendezvous will result in an overburn of about 6 FPS. This is because 2.5 seconds of ullage are not taken into account, and the thrust buildup constant is not correct for a "wet start." Recognition: N85 display of about 6 FPS magnitude. Recovery: Trim out as is usually done.

ROUTINES

R03

24. 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: 1204 alarm with V37 flash. Recovery: Recall present program and R03.

R10

25. The altitude rate displayed on the tape meter during descent or ascent may not be smooth in certain cases. One out of four outputs to the meter may be incorrect by a small amount, resulting in jerky motion of the meter.

25a. The crosspointers displaying forward and lateral velocity during descent may be incorrect by up to 3.6 feet per second. Therefore in a manual landing, the attitude error needles on the FDAI should be used as the primary means of nulling the horizontal velocities.

VERBS - NOUNS

26. 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.

27. 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, V34E) to either a blank DSKY or a non-flashing display.

28. 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.

29. 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)
V06N05 in P20
V16N80 in P20
V05N09 in P22 (Alarm codes 501, 503, 514, 525, 530)
V50N72 in P20 and P22

30. 3.1.2 No astronaut initiated verb/noun is restart protected. Recovery: Reselect verb/noun.

31. 3.2.1 Restart will terminate extended verbs. Recovery: Reselect extended verb.

V30, V31

32. 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. Recoginition: Unexpected DSKY displays or activity. Recovery: Standard recovery (documented in crew checklist).

V37

33. 1.2.2 If V37 is attempted or a restart occurs 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.

34. 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.

V83

35. 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.

V89

36. 1.2.8 If a V89 is attempted during P00 with no valid REFSMMAT, a program alarm 00220 and a flashing V37 will result. Any attempt to select another extended verb with displays at this time will result in OPERATOR ERROR. The flashing V37 should be responded to by keying 00E before further keyboard activity.

V96

37. 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.

NOUN

38. 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.

N49

39. 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.

N83
N85

40. 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 1/2 - 1 1/2 sec. delay between application of ΔV and the visible result.

1. 1.2.5 If RR is in Mode I1, 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.

2. Following a restart in P40, the Delta-V increment may be subtracted from V_g twice. This is indicated by V_g (R2 of N40) dropping by twice the amount of ΔV accumulated in the past 2 seconds. This is not accompanied by a similar gain in DV total R3 of N40). This causes the LGC to command an underburn , such that at the end of the burn, DV total will not be equal to the targeted VG. Recovery: Add appropriate ΔV manually at the end of burn (Null N 85); for DO1, normally 8.7 fps at 40% throttle. (L-1C-)1)

P65

3. 1.7.6 If a landing is attempted in P65, a PRO at touchdown to N60 will only temporarily zero attitude error; the automatic guidance may want a new attitude and thus cause jet firings. Recovery: Go to ATT HOLD and PRO again to N60. Avoidance: Land in ATT HOLD.

R29

4. 1.6.3 R29 (Powered Flight RR designate routine) does not work. The routine will continue designation throughout ascent, but never lock on. (L-1B-02) Avoidance: RR mode switch in SLEW or AUTO, i.e., not in LGC.

V59

5. If a V59E is used to reposition the Landing Radar antenna to position two at any time other than powered descent in P63, the return from the repositioning routine will be incorrect. As a result, V61 will also be executed, which will cause DAP attitude errors to be displayed on the FDAI. Furthermore, if the repositioning is not successful, the 523 alarm will not be given. Also, all subsequent radar operations using the RADSTALL routine as a buffer will return with the status of the previous radar operation. This will remain in effect until a V37 or a restart occurs. Avoidance: Do not use V59 other than during powered descent in P63. Recovery: If in P00, reselect P00, or V 69 E.

V90

6. 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.

V92

7. 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.