POO—LGC IDLING PROGRAM

Purpose:
1. To maintain the LGC in a condition of readiness for entry into other programs.
2. To update the CSM and LM state vectors every four time steps.

Assumptions:
1. This program is automatically selected by V96E, which may be done during any program. State vector integration is permanently inhibited following V96E. Normal integration functions will resume after selection of any program or extended verb. POO integration will resume when POO is reselected. Usage of V96 can cause incorrect W-matrix and state vector synchronization.

2. Program changes are inhibited during integration periods and Program Alarm 15203 will occur if a change is attempted when inhibited.

Sequence of Events:
V37E00E
V06N38E
V06N36

PO6—LGC POWER DOWN PROGRAM

Purpose:
1. To transfer the LGC from the Operate to the Standby program.

Assumptions:
1. If the computer power is switched off, the LGC Update program (P27) would have to be performed to update the LM and CSM state vectors and computer clock time.
2. The LGC is capable of maintaining an accurate value of ground elapsed time (GET) for only 23 hours when in the Standby mode. If the LGC is not brought out of the standby condition to the running condition at least once within 23 hours, the LGC value of GET must be updated.

Sequence of Events:
V37E06E
V50N25

P12—POWERED ASCENT PROGRAM

Purpose:
1. To control the PGNS during countdown, ignition, thrusting, and thrust termination of PGNS controlled APS powered ascent maneuver from the lunar surface.
Assumptions:

1. The LGC has stored injection values which define an ascent trajectory that will result in an orbit coplanar with the CSM orbit and an apolune of 30 nmi. These values at orbit insertion are attitude, distance between the LM and CSM orbital planes, LM vertical (V(R)), LM horizontal (V(Y)), and LM downrange (V(Z)) velocities. All attitudes are measured with respect to the LGC stored landing site vector.

2. The PGNS will control the LM ascent maneuver such that the LM injection velocity is in the CSM orbital plane or parallel to it at a distance specified by the astronaut inserted crossrange. The injection conditions can be modified by changing the nominal downrange and radial velocities displayed.

3. Engine ignition may be slipped beyond TIG if desired by the crew or if the state vector integration cannot be completed in time. Variation of the time of ascent integration (TIGAS) changes the relative phasing of the ascent trajectory with respect to the CSM. This option is inhibited from TIGAS until 12 seconds after V(R) equals 40 ft/s.

4. The initial period of the ascent trajectory consists of two phases:
   a. Vertical Rise Phase. From TIG until the LM radial velocity (V(R)) exceeds 40 ft/s. During this phase, the PGNS holds the LM attitude with the +X axis parallel to the LM position vector at TIG. At TIG, the PGNS commands the LM around its X axis (yaw) until the LM +Z axis points downrange.
   b. Pitchover Phase. When V(R) exceeds 40 ft/s. During this phase, the PGNS commands the LM to pitch down (about the Y axis) an amount defined by the guidance equations.

5. Normally, the Lunar Surface Align program (P57) has been completed and leaves the LM aligned at a known orientation.

6. The X-ray override option provides the crew with the ability to exercise manual control about the LM X-axis with the attitude controller even though the PGNS controls the LM attitude. This option is inhibited from TIGAS until 12 seconds after V(R) equals 40 ft/s.

7. Either the Load DAP routine (RO3) or the Landing Confirmation program has been performed prior to selection of this program. The DAP will be energized when the PGNS Control mode and the Auto Attitude or Attitude Hold Control mode have been selected. If this occurs prior to the PGNS autocheck in this program, the attitude errors will be zeroed and the attitude deadband will be set to the value specified by P88 (5 degrees) or RO3 (astronaut defined), whichever occurred more recently. Immediately prior to the PGNS autocheck, this program will set the attitude deadband to 1 degree.

8. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Automatic, the PGNS controls the total vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about only the yaw axis with the ACA (X-axis override) provided the X-axis override capability is permitted (see Assumption 7). If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS holds the vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise manual control about all vehicle axes with the ACA using either the Rate Command or Minimum Impulse mode. However, it is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.

9. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Automatic, the PGNS controls the total vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about only the yaw axis with the ACA (X-axis override) provided the X-axis override capability is permitted (see Assumption 7). If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS holds the vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise manual control about all vehicle axes with the ACA using either the Rate Command or Minimum Impulse mode. However, it is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.

10. Control of the LM RCS and AGS is transferred from the PGNS to the Abort Guidance System (AGS) by changing the Guidance Control switch from PGNS to AGS. The AGS is capable of taking control of the LM during any phase of the lunar ascent and guiding it to a safe orbit and should be initialized by manual selection of R47, the AGS Initialization routine, prior to the selection of P12.

11. The PGNS generates two types of errors for display on the FDAI as selected by the astronaut:
   a. Mode 1 — Selected by Verb 61. Autopilot following errors used as a monitor of the DAP’s ability to track automatic steering commands.
   b. Mode 2 — Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.

12. This program is selected by the astronaut at least 6 minutes prior to ignition.

Sequence of Events:

V37E12E
Flashing
V02N73
Ascent Time of Ignition
PRO
V25E
Load New TIG

V99N74
Desired Downrange Velocity
PRO
V24E
Load New Downrange and Crossrange

V50N25
Checklist Code
PRO
V06N74
Switch Guidance Control — PGNS
Mode Control — Auto

V06N74
Time from Ignition
FDII Yaw — After Vertical Rise
FDII Pitch — After Vertical Rise

TFI counts down until TIG -35 seconds, when DSKY blanks for 5 seconds.

V06N74
FDII Yaw — After Vertical Rise
FDII Pitch — After Vertical Rise

V06N94
Astronaut okays ignition. TIG occurs.

V06N94
VGY
Altitude Rate
N78E
V06N76
Desired Downrange Velocity

V16N77
Time to Engine Cutoff

V16N77
Velocity Normal to CSM Plane

V16N77
Absolute Value of Velocity
LM-44
P12 (continued)

KEY REL

Flashing VOX
V16N94 Attitude Rate XXXX X ft/s
Computed Attitude XXXXX . It

PRO

Flashing Velocity to be Gained (X Body) XXXX.X ft/s
V16N85 Velocity to be Gained (Y Body) XXXX.X ft/s
Velocity to be Gained (Z Body) XXXX.X ft/s

Null Residual Velocities

V63E

Flashing Range XXX.XX nmi
V16N4 Range Rate XXXX.X ft/s
Theta XXXXX deg

LM-45
P20 (continued)

c. Selection of a new program from a program which had turned on Average G.

d. Initialization of the W matrix.

e. Completion of RR search routine (R24) in P20.

The crew may manually adjust the LGC-stored values of RR shaft and trunnion bias by a direct load of four registers. However, unless the RR has been jarred, the LGC bias estimate should be more accurate than that from another sources.

6. The selection and termination of P20, P22, and P26 are subject to special operating procedures different from all other programs:

a. Selection
1. Always by V32EXXE.
2. If any other program is running at the time of P20/22/26 selection the new program will replace the old. This includes P20/22/26 selection whenever either P20, P22, or P26 is running.
3. If P20 or P26 is running, selection of any program other than P00 or P22 will result in P20 or P22 continuing and the new program also operating with its number in the DSKY program lights.
4. If P20 or P26 is running, selection of P00 or P22 will result in the termination of the old program and operation of the new.

b. Termination
1. By selection of P00, V56E, or by V34E.
2. P00 selection will terminate P20, 22, and P26 and any other program in process and establish P00.
3. V56E selection will set the Terminate Tracking routine (R58) which will terminate only P20 or P26 if either of these programs is running in conjunction with another program. In all other cases R56 will select R00. V56E may be performed any time during P20, 22, or 26 operation.
4. The LGC will act upon V34 only in response to a flashing verb-noun. If this display was originated by P20, P22, or P26, V34E will result in an LGC response identical to that of V56E; that is, selection of R56 except in the case of a V00N49 display. If this display was not originated by P20, P22, or P26, the LGC will go to P00; however, the program in the background will continue. The new program selected follows the selection rules above.

A through is not clearly shown in the program flow below, a V34 response to a priority display must be delayed 2 seconds from display initiation whereas the delay is not necessary for a V56E response. A lamp is lighted in the DSKY for a priority display.

7. The RR Manual Acquisition routine (R23) may be selected only if P20 is not running in conjunction with another program.

8. When P20 is selected any time prior to the landing phase in the lunar mission, this program must be operated in the no update mode to prevent modifying a precision descent targeting for landing.

9. The RSS position and velocity errors computed from the W matrix are available by Extended Verb (V67E). Based upon values in this display and the details of the mission, the astronaut can elect to stop or continue the current navigation procedure or to reinitialize the W matrix and continue navigating. The capability to reinitialize the W matrix is also provided via V67E.

10. State vector integration may be permanently inhibited by V96E. This entry will terminate all present programs and select the LGC falling program (P00) with the P00 automatic state vector integration permanently inhibited until selection of another program. Use of V96 can cause incorrect W-matrix extrapolation since state vector synchronization is not maintained.

Sequence of Events:

V03E20E
V80E or V81E or V96E

State Vector Option

V80E — LM, V81E — CSM, V96E — None
RR Mode Switch — In LGC

Flashing RR Trunnion Angle XXX.XX deg
V60N72 RR Shaft Angle XXX.XX deg

Verify main lobs lockon
If RR locked on and tracking. No Track light out, DSKY blanks RR taking marks.

Range XXX.XX nmi
Range Rate XXX.X ft/s
Time from Ignition XXbXX mins

KEY REL
Flashing Delta R Delta V Data Source Code
VO6N49 XXX.XX nmi XXX.X ft/s 0000X

V2E Reject partial mark
V34E Reject total mark
PRO Update with mark
Flashing (see above display)
VO6N49

To terminate: V56E or V37E00E or V34E during a flashing display. To keep P20 running in the background: V37EXXE.

If pointing angle greater than 15 degrees.

Flashing Desired Automaneuver to FDA Ball
VO6N18 Angles
R XXX.XX deg
P XXX.XX deg
Y XXX.XX deg

Automaneuver: Guidance Control — PGNS
: Mode Control — PGNS Auto

PRO
Monitor maneuver to attitude.
Manual Maneuver: Mode Control — PGNS Attitude Hold, then maneuver.

Flashing Desired Automaneuver to FDA Ball
VO6N18 Angles
R XXX.XX deg
P XXX.XX deg
Y XXX.XX deg

When maneuver is complete, by either method, select mode of RR acquisition of CSM.

ENTER Manual RR acquisition. RR Mode switch: Auto or Slew
Flashing Checklist Code
V50N25 00201

ENTER Choose RR acquisition mode.
Flashing Checklist Code
V50N25 00205

Perform manual acquisition of CSM with RR. Slew RR for lockon. RR Mode switch — LGC. No Track light is off. Wait 10 seconds.

PRO
Flashing Trunnion Angle Shaft Angle
V50N72 XXX.XX deg XXX.XX deg

Verify main lobe lockon.

Lw-47
P20 (continued)

PRO
DSKY blanks; No Track light is out; RR taking marks.
Flashing Delta R Delta V Data Source Code (see above)
VO6N49 XXX.XX nmi XXX.X ft/s 0000X

V32E Reject partial mark.
V34E Reject total mark.
PRO Update with mark.
Flashing (see above display and response options)
VO6N49

Automatic RR acquisition.
RR Mode switch — LGC.
Flashing Trunnion Angle Shaft Angle
V50N72 XXX.XX deg XXX.XX deg

PRO
No Track light is on.
Flashing Alarm Code
VO6N09 00503

RR data no good for 30 seconds or Designate fails.

V32E Redesignate to new V50N72 display.

PRO
Start Search mode.
Flashing Data Indicator
V16N80 00003 — Search
32 seconds scan
11111 — Lockon
Angle Between LOS and LM +Z Axis XXX.XX deg

PRO
When lockon occurs automatically, DSKY blanks; No Track light out; RR taking marks after PRO.
Flashing Delta R Delta V Data Source Code (see above)
VO6N49 XXX.XX nmi XXX.X ft/s 0000X

V32E Reject partial mark.
V34E Reject total mark.
PRO Update with mark.

To terminate: V56E or V37E00E or V34E during a flashing display.
To keep P20 running in the background: V37EXXE.

P21—GROUND TRACK DETERMINATION

Purpose:
1. To provide astronaut with details of his ground track.

Assumptions:
1. Vehicle whose ground track parameters are calculated remains in freefall from start of program until T LAT/LONG.
2. Program may be selected while LM is either in earth or lunar orbit to define ground track of either LM or CSM.
P22—LUNAR SURFACE NAVIGATION PROGRAM

Purpose:
1. To control the Rendezvous Radar (RR) to acquire and track the CSM while the LM is on the lunar surface.
2. To update the CSM state vector on the basis of RR tracking data.
3. To track the CSM without updating either vehicle state vector.

Assumptions:
1. Normally the Lunar Surface Alignment program (P57) would be completed before using P22.
2. The CSM may be above or below the horizon, outside the available RR coverage sector, or outside the allowable RR coverage sector.
3. The program will always track the CSM with the radar in Mode 2, whose available coverage is always less than horizon to horizon.
4. The CSM is maintaining a preferred tracking attitude that correctly orients the CSM transponder for RR tracking of the LM.

At the beginning of the program the state vector update option is automatically set to the CSM, which may be inhibited at any time and later restored by the following manual entries:

a. V81E — Update CSM state vector.
b. V95E — No state vector update.

c. State vector update from the ground (P27).

v37E21E. Key in vehicle desired.

PRO
v06n34

V22EXXE. Time of LAT/LONG 00Xxx. h VO6N34 Ground Track Longitude XXX.XX deg (+ east) Altitude Above Ground XXXX.X nmi

v06n81

V06n8t

V25E. Load desired time. (time = 0 specifies present time)

PRO
v06n43

Ground Track Longitude XXX.XX deg (+ east) Altitude Above Ground XXXX.X nmi

v32E

Repeat program from Time of LAT/LONG with new loaded time,
or

v37

Select New Program.
Sequence of Events:

V81E  CSM state vector update allowed or V9SE  No update of either state vector allowed.

V37E22E Flashing Option Code ID 00012 (CSM orbit option) Option 0000X (1—No orbit change 2—Change orbit to Passover LM) V22E load desired option

PRO 00002 Flashing Time of Ascent Ignition 00XXX h Option V06N33 min Only 0XX.XX s

If range is greater than 400 nmi and range rate is greater than 0, V56E — exit P22 If range is greater than 400 nmi and range rate is less than 0 (closing) wait until range is less than 400 nmi.

PRO V16N54E Range XXX.XX nmi Range Rate XXX.XX ft/s Theta XXX.XX deg

Automatic Acquisition: RR Mode Switch — LGC; No Track light — out; DSKY — blanks; RR taking marks. (P22 runs in background.)

V16N78E Range XXX.XX nmi Range Rate XXX.XX ft/s Time from Ignition XXbXX min/s

KEY REL V16N72E RR Trunnion Angle XXX.XX deg RR Shaft Angle XXX.XX deg

KEY REL Flashing Delta Range XXX.XX nmi Delta Velocity XXX.XX ft/s Radar Data Source Code 0000X (X = 1 range) (X = 2 range rate)

V32E Reread RR. Flashing V06N49 display repeats. Monitor display, PRC when desired to update state vectors.

PRO Update — DSKY blanks; RR taking marks: P22 runs in the background. No Track light is on. RR not tracking.

Flash Indication Alarm Code 00503 (RR designate fall)

Sequence of Events:

V37E25E When attitude error is greater than 15 degrees.

Flash Indication Desired Automaneuver FDAI Angles XXX.XX deg

For Automaneuver: Guidance Control — PGNS Mode Control — PGNS Auto

PRO For Manual Maneuver: Guidance Control — PGNS Mode Control — PGNS Attitude Hold and then maneuver
LM-52
P25 (continued)

Flashing Desired Automaneuver FDAI Angles
R XXX.XX deg
P XXX.XX deg
Y XXX.XX deg

ENTER P25 continues in background until terminated by V66E.

P27—LGC UPDATE

Purpose
1. To enter data into the LGC via the digital uplink or by crew input via the DSKY.

Assumptions:
1. LGC updates are of four categories:
   a. Provide a decrement for the LGC clock and the orbital integration state vector time tags, and an increment for TEPHEM (V70).
   b. Provide load capability for a block of sequential erasable locations 1 through 18 whose addresses are specified (V71).
   c. Provide load capability for individual erasable locations 1 through 9 (V72).
   d. Provide an octal increment for the LGC clock only (V73).
2. The uplink may be blocked by placing the Voice/Off/Voice BU switch to Voice BU.
3. Update is allowed in the LM only when the LGC is in the LGC Idling program (P00). P27 exit is always to P00.

P30—EXTERNAL DELTA V PROGRAM

Purpose
1. To accept targeting parameters obtained from a source(s) external to the LGC and compute therefrom the required velocity and other initial conditions required by the LGC for execution of the desired maneuver. The targeting parameters inserted into the LGC are the time of ignition (TIG) and the impulsive Delta V along LM local vertical axes at TIG.

Assumptions:
1. The target parameters (TIG and Delta V (LV)) may have been loaded from the ground during a prior execution of P27.
2. The External Delta V flag is set during this program to designate to the thrusting program that External Delta V steering is to be used.
3. The ISS need not be on to complete this program unless the Rendezvous Radar is to be used for automatic state vector updating by the Rendezvous Navigation program (P20).
4. The Rendezvous Radar may or may not be used to update the LM or CSM state vectors for this program. If radar use is desired, the ISS should be in operation and the radar should have been turned on and locked on the CSM by previous selection of P20. Radar sighting marks will be made automatically approximately once a minute when enabled by the Track and Update flags.
5. This program is applicable in either earth or lunar orbit.

LM-53
P30 (continued)

Sequence of Events:

V37E30E
Flashing Time of ignition XXXX.XX s
V25E Load New TIG
Flashing X XXX.XX ft/s
Flashing Y XXX.XX ft/s
Flashing Z XXX.XX ft/s
V25E Load Desired ΔV
Flashing X XXX.X X nmi
Flashing Y XXX.X X nmi
Flashing Z XXX.X ft/s
Flashing Marks XXXXX marks
V16N45 Time Until Next Burn XXX.XX min/s
Flashing Middle Gimbal Angle XXX.XX deg
Flashing Select New Program

P32—LGC COELLIPTIC SEQUENCE INITIATION (CSI) PROGRAM

Purpose:
1. To calculate parameters associated with the following concentric flight plan maneuvers: the Coelliptic Sequence Initiation (CSI) and the Constant Delta Altitude maneuver (CDH), for Delta V burns.
2. To store the CSI target parameters for use by the desired thrusting program.

Assumptions:
1. At a selected TP! time the line of sight between the LM and the CSM is selected to be a prescribed angle (E) from the horizontal plane defined at the active position.
2. The time between CSI ignition and CDH ignition must be computed to be greater than 10 minutes for successful completion of the program.
3. The time between CDH ignition and TP! ignition must be computed to be greater than 10 minutes for successful completion of the program.
4. CDH Delta V is selected to minimize the variation of the altitude difference between the orbits.
5. CSI burn is defined such that the impulsive Delta V is in the LM horizontal plane at CSI ignition.
6. The pericenter altitude of the orbit following CSI and CDH must be greater than 35,000 ft (lunar orbit) or 85 nmi (earth orbit) for successful completion of this program.
7. The CSI and CDH maneuvers are originally assumed to be parallel to the plane of the CSM orbit. However, crew modification of Delta V (LV) components may result in an out-of-plane CSI maneuver.
9. The ISS need not be on to complete this program unless the Rendezvous Radar is to be used for automatic state vector updating by the Rendezvous Navigation program (P20). P20 will define the status of the ISS.

Sequence of Events:

V32E
Flash Time of CSI Ignition/T(APOAPSIS) 00XXX h
V09N11 000XX min 0XXX s

V25E Load desired CSI TIG

PRO
If zero or negative time, time of APOAPSIS will be computed and displayed by N11.

PRO
Flash Number of Apsidal Crossings 0000X
V09N55 Elevation Angle XXX.XX deg
Central Angle of Passive Vehicle XXX.XX deg

V25E Load desired data.

Apsidal crossing is the future line of apsis of the active vehicle.

Elevation angle is the angle between the LM/CSM LOS and the LM local horizontal plane. CENTANG is an option code where R3 # 0 specifies TIG(CDH) to occur at N(180) degrees from CSI maneuver and N = number entered in R1.

For CSM solution (P72), angle is between CSM/LM LOS and the CSM horizontal.

PRO
Flash Time of TPI Ignition 00XXX h
V09N37 000XX min 0XXX s

PRO
Flash Marks V16N45

PRO
Flash Time from Ignition of Next Burn XXXXX min/s
Middle Gimbal Angle -00001

PRO
Set Final flag.

V32E continues in program but Final flag is not set. Used when another pass is desired.

Alarm codes 00800 through 00900 may occur. If an alarm occurs, V32E recycles to V09N11 where the input parameters may be adjusted for a new solution.

PRO
Flash Delta Altitude (CDH) XXXXX X nmi
V09N75 ΔT (CSI - CDH) XXXXXX min/s
ΔT (CDH - TPI) XXXXXX min/s

PRO
Flash ΔV_X (LV) for CSI V09N81 ΔV_Y (LV) for CSI
ΔV_Z (LV) for CSI XXXXX X ft/s

V09E To correct for out-of-plane velocity on final pass.

Flash Time of Event 00XXX h V09N16 000XX min 0XXX s

PRO
If zero or negative time, time of APOAPSIS will be computed and displayed by N11.
3. The ISS need not be on to complete this program unless automatic state vector updating is desired by the Rendezvous Navigation program (P20). If selected, P20 will define the status of the ISS.

Sequence of Events:

V37E33E
Flashing Time of Ignition (CDH) 00XXX h
V06N13
00XX, min
0XX.XXs

PRO
V25E Load desired TIG.

PRO
Set Final flag.
V32E continues in program but Final flag is not set. Used when another pass is desired.
If an alarm occurs, a V32E may be used to recycle the V06N13 and readjust TIG.

Flashing Delta Altitude (CDH) XXXX.X nmi
V06N75
ΔT (TP1 - CDH)
ΔT (TP1 - Nom TP1)

PRO
Flashing ΔVx (LV) for CDH XXXX.X ft/s
V06N81
ΔVy (LV) for CDH XXXX.X ft/s
ΔVz (LV) for CDH XXXX.X ft/s

To correct for out-of-plane velocity on final pass.

V90E
Flashing Time of Event 00XXX h
V06N16
00XX, min
0XX.XXs

PRO
V25E Load desired TIG.

PRO
Flashing Out-of-plane Distance XXXX.X nmi
V06N90
Out-of-plane Velocity (YDOT) XXXX.X ft/s
Pa

PRO
Record out-of-plane velocity.

PRO
Flashing ΔVx (LV) for CSI XXXX.X ft/s
V06N81
ΔVy (LV) for CSI XXXX.X ft/s
ΔVz (LV) for CSI XXXX.X ft/s

V22E Load — YDOT recorded above.

PRO
If Final flag is not set, go to previous flashing V16N45 display.

Flashing Marks XXXXX
V16N45
Time from Ignition XbXX min/s
Middle Gimbal Angle XXXX.XX deg

Middle gimbal angle (MGA) will be MGA at TIG(CDH).
If the IMU is not aligned, MGA will be -00002.
For CSM solution (P73) MGA is always -00002 on the final pass.

PRO
Select New Program
V37
Elevation angle (E) is the angle between the LM/CSM LOS and the LM local horizontal at TIG(TPI). E should be $+00000$ if E is to be computed for the specified TIG.

For CSM solution (P74) the angle is between the CSM/LM LOS and the CSM local vertical at TIG.

**PRO**

Flashing Marks XXXXX
V16N45 Time from Ignition XXbXX min/s
Middle Gimbal Angle 00000

**V32E** continues the program but Final flag is not set. Used when another pass is desired.

**PRO**

Set Final flag.

If elevation angle for given TIG is to be computed.

Flashing Same as N55 above except elevation angle has been computed.

TIG for given elevation angle if elevation angle above was $\neq 0$.

Flashing Time of Ignition 00000 h
V06N37 000XX min

**PRO**

Flashing Pericenter Altitude XXXXX X nmi
V06N58 Delta V (TPM)
V06N81 Delta V (TPF)

**PRO**

Flashing Marks XXXXX
V16N45 Time from Ignition XXbXX min/s
Middle Gimbal Angle XXX.XX deg

Middle Gimbal Angle (MGA) will be MGA at TIG (TPM). If the IMU is not aligned, MGA will be -00002. For CSM solution (P75) MGA is always -00002 on final pass.

**PRO**

Flashing Select New Program V37

**P35—LM TRANSFER PHASE MIDCOURSE (TPM) PROGRAM**

**Purpose:**

1. To calculate the required Delta V and other initial conditions required by the LGC for LM execution of the next midcourse correction of the transfer phase of an active LM rendezvous.

**Assumptions:**

1. The ISS need not be on to complete this program, unless automatic state vector updating is desired by the Rendezvous Navigation program (P20). If selected, P20 will define the status of the ISS. 

2. The Rendezvous Radar is on and is locked on the CSM. This was done during previous selection of P20. Radar sighting marks will be made automatically approximately once a minute when enabled. The rendezvous tracking mark counter is zeroed after the selection of P20 and after each thrusting maneuver.

3. The time of intercept (TINT) was defined by previous completion of the Transfer Phase Initiation (TPI) program (P34) and is presently available in LGC storage.

4. Once the parameters required for computation of the maneuver have been completely specified, the value of the active vehicle central angle of transfer is computed and stored. This number will be available for display to the astronaut through the use of V06 NS2.

The astronaut would call this display to verify that the central angle of transfer of the active vehicle is not within 170 to 190 degrees. If the angle is within this zone the astronaut should reassess the input targeting parameters based upon Delta V and expected maneuver time.

**Sequence of Events:**

**V32E35E**

Flashing Marks XXXXX
V16N45 Time from Ignition XXbXX min/s
Middle Gimbal Angle 00001

**PRO**

Flashing AV (LV) for TPM XXXXX X ft/s
V06N63 AV (LV) for TPM XXXXX X ft/s
AVz (LV) for TPM XXXXX X ft/s

**PRO**

Flashing Marks XXXXX
V16N45 Time from Ignition XXbXX min/s
Middle Gimbal Angle XXX.XX deg

Middle Gimbal Angle (MGA) will be MGA at TIG (TPM).

If the IMU is not aligned, MGA will be -00002.

For CSM solution (P75) MGA is always -00002 on final pass.

**PRO**

Flashing Select New Program V37

**P40—DPS PROGRAM**

**Purpose:**

1. To compute a preferred IMU orientation and a vehicle attitude for a LM DPS thrusting maneuver and to maneuver the vehicle to that attitude.

2. To control the PGNS during countdown, ignition, thrusting, and thrust termination of a PGNS controlled DPS maneuver.

**Assumptions:**

1. The target parameters have been calculated and stored in the LGC by prior execution of a prethrusting program.

2. The required steering equations are identified by the prior prethrust program, which either reset ("ASTEER") or set (External Delta V) the External V flag. For External Delta V steering, VG is calculated once for the specified time of ignition. Thereafter both during DPS thrusting and until the crew notifies the LGC that RCS trim thrusting has been completed, the LGC updates VG only as a result of accelerometer inputs.
For steering control when using "ASTEER," the velocity required is calculated from the most recent intercept trajectory semimajor axis. The Lambert routine periodically recomputes the intercept trajectory semimajor axis for the "ASTEER" calculations. The interval between Lambert solutions is controlled by an erasable lead value (UL).

3. Engine ignition may be slipped beyond the established TIG if desired by the crew, or if attitude vector integration cannot be completed in time.

4. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Auto, the PGNS controls the total vehicle attitude and generates either Model 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about only the yaw axis with the ACA (X-axis override) provided the X-axis override capability is permitted.

If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS holds the vehicle attitude and generates either Model 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise manual control about the vehicle axis with the ACA using either the Rate Command or Minimum Impulse mode. However, it is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.

If the Guidance Control switch is changed from PGNS to AGS during a thrusting maneuver, the LGC continues computation of position, velocity, desired thrust vector, and desired attitude errors.

5. The PGNS generates two types of errors for display on the FDAI as selected by the astronaut:
   a. Mode 1 — Selected by Verb 61. Autopilot following errors used as a monitor of the DAP's ability to track automatic steering commands.
   b. Mode 2 — Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.

6. The X-axis override option provides the crew with the ability to exercise manual control about the LM X-axis with the attitude controller even though the PGNS Attitude Control mode is Auto. When the controller is returned to detent, the DAP electronics store the yaw rate when the yaw rate is damped, and then maintains that attitude.

The X-axis override option is always available to the crew. However, it should not be exercised when the LGC is specifying desired yaw attitude that is different from the attitude maneuver to the thrusting attitude.

7. When the thrust/translation controller is set to minimum thrust position and the LGC throttle command is zero, the DPS will start at 10 percent thrust.

8. The Load DAP Data routine (R03) has been performed prior to selection of this program and the DPS engine gimbal has been previously driven to the correct trim position. If this burn is of sufficient duration that vehicle transients at ignition due to CG/thrust do not affect accomplishment of maneuver aim conditions, then the gimbal need not be driven to the trim position before TIG. Driving the gimbal to the trim position in worst case conditions could require 2 minutes.

9. During DPS burns only, the pitch-roll RCS jet autopilot (U and V jets) may be disabled by (V65) or enabled by (V75). This capability is intended to be used to prevent LM descent stage thermal constraint violations during CSM-occupied DPS burns. The capability exists during P63 and P70 also. Performance of FRESH START (V36E) will always enable the capability in the autopilot.

10. The LGC will neither designate nor read the Rendezvous Radar (RR) during this program.

11. This program should be selected by the astronaut by DSKY entry at least 5 minutes before the estimated time of ignition.

12. The value of Delta V required will be stored in the local vertical coordinate system and is available during this program by keying V06 NS1E.
Purpose:
1. To compute a preferred IMU orientation and a vehicle attitude for an RCS thrusting maneuver and to perform the vehicle maneuver to that attitude.
2. To provide suitable displays for manual execution of the thrusting maneuver in the Attitude Hold mode.

Assumptions:
1. The target parameters have been calculated and stored in the LGC by prior execution of a prethrusting program.
2. The required steering equations are identified by the prior prethrust program, which either resets ("ASTEER") or sets (External Delta V) the External Delta V flag. For External Delta V steering, VG is calculated once for the specified time of ignition. Thereafter until the crew resets the LGC that RCS thrusting has been completed, the LGC updates VG only as a result of accelerometer inputs.

For steering control when using "ASTEER," the velocity required is calculated from the most recent intercept trajectory semimajor axis. The Lambert routine periodically recomputes the intercept trajectory semimajor axis for the "ASTEER" calculations. The interval between Lambert solutions is controlled by an erasable load value (UT).

3. RCS ignition may be slipped beyond the established TIG if desired by the crew, or if state vector integration cannot be completed on time.
4. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS holds the vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise manual control about all vehicle axes with the ACA (X-axis override) provided the X-axis override capability is permitted.

5. The PGNS generates two types of errors for display on the FDAI as selected by the astronaut:
   a. Mode 1 — Selected by Verb 61. Autopilot following errors used as a monitor of the DAP's ability to track automatic steering commands.
   b. Mode 2 — Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.
6. The X-axis override option provides the crew with the ability to exercise manual control about the LM X axis with the attitude controller even though the PGNS Attitude Control mode is Auto. When the controller is returned to detent, the DAP damps the yaw rate, stores the yaw attitude when the yaw rate is damped, and then maintains that attitude.
7. The Load DAP Data routine (RO3) has been performed prior to selection of this program.
8. The LGC will neither designate nor read the Rendezvous Radar (RR) during this program.
9. This program should be selected by the astronaut by DSKY entry at least 5 minutes before the estimated time of ignition.
10. The value of Delta V required will be stored in the local vertical system and is available in this program until Average G turns on by keying in VS0N81E.

Sequence of Events
V37E41E

Flashing: Desired Automanuever to FDAI Ball
VS0N18 Angles

Automanuever: Guidance Control — PGNS
Mode Control — PGNS Auto

P42—APS PROGRAM

Purpose:
1. To compute a preferred IMU orientation and vehicle attitude for an LM APS thrusting maneuver and maneuver the vehicle to that attitude.
2. To control the S/C during countdown, ignition, thrusting, and thrust termination of a PGNS-controlled APS maneuver.

Assumptions:
1. The target parameters have been calculated and stored in the LGC by prior execution of a prethrusting maneuver.
2. The required steering equations are identified by the prior prethrust program, which either resets ("ASTEER") or sets (External Delta V) the External Delta V flag. For External Delta V steering, VG is calculated once for the specified time of ignition. Thereafter until the crew determines that APS thrusting has been completed, the LGC updates VG only as a result of accelerometer inputs.

For steering control when using "ASTEER," the velocity required is calculated from the most recent intercept trajectory semimajor axis. The Lambert routine periodically recomputes the intercept trajectory semimajor axis for the "ASTEER" calculations. The interval between Lambert solutions is controlled by an erasable load value (UT).

3. Engine ignition may be slipped beyond the established TIG if desired by the crew or if state vector integration cannot be completed in time.
4. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Auto, the PGNS controls the total vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about only the yaw axis with the ACA (X-axis override) provided the X-axis override capability is permitted.
If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS holds the vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise manual control about all vehicle axes with the ACA using either the Rate Command or Minimum Impulse mode. However, it is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.

5. The PGNS generates two types of errors for display on the FDAI as selected by the astronaut:
   a. Mode 1 — Selected by Verb 61. Autopilot following errors used as a monitor of the DAP's ability to track automatic steering commands.
   b. Mode 2 — Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.

6. The X-axis override option provides the crew with the ability to exercise manual control about the LM X axis with the attitude controller even though the PGNS Attitude Control mode is Auto. When the controller is returned to default the PGNS damps the yaw rate, stores the yaw attitude when the yaw rate is damped, and then maintains that attitude.

The X-axis override option is always available to the crew. However, it should not be exercised when the LGC is specifying a desired yaw attitude; that is, during the attitude maneuver to the thrusting attitude.

7. The Load DAP Data routine may have been performed prior to selection of this program.

8. The LGC will neither designate nor read the Rendezvous Radar (RR) during the program.

9. This program should be selected by the astronaut by DSKY entry at least 5 minutes before the estimated time of ignition.

10. The value of Delta V required will be stored in the local vertical system and is available in this program until Average G turns on by keying V06N81E.

Sequence of Events:
V37E42E

Flashing Desired Automaneuver to FDAI Ball
V60N18 Angles
R XXX.XX deg
P XXX.XX deg
Y XXX.XX deg

Automaneuver: Guidance Control — PGNS
Mode Control — PGNS Auto

PRO
Monitor maneuver. At end of maneuver flashing V60N18 display appears.

Manual Maneuver: Guidance Control — PGNS
Mode Control — PGNS Attitude Hold

Maneuver to V60N18 displayed angles.

ENTER
V06N40 Time from Ignition
Velvet to be Gained
ΔV (accumulated)

TFI counts down until TIG - 35 seconds when DSKY blanks for 5 seconds. V06N40 display returns until TIG - 5 seconds.
Sequence of Events:

Flashing Checklist Code 00015

Purpose:

1. To determine the inertial orientation of the IMU using sightings on two celestial bodies with the AOT or a backup optical system.

Assumptions:

1. There are no restraints upon the LM attitude control modes until a PGNS controlled maneuver is called by a program or the crew wishes to manually maneuver the vehicle.

2. Time and RCS fuel may be saved, and subsequent IMU alignment decisions greatly simplified, if this program is performed in such a way as to leave the IMU inertially stabilized at an orientation as close as possible to the optimum orientation sequence followed by future LGC programs.

3. Extended verbs should not be exercised during this program because of possible interference with the AOT Mark routine (RS3).
LM-68

P52—IMU REALIGN PROGRAM

Purpose:

1. To align the IMU from a “known” orientation to one of four orientations selected by the astronaut using sightings on two celestial bodies with the AOT or a backup optical system.
2. Preferred Orientation (Option 00001). An optimum orientation for a previously calculated maneuver. This orientation must be calculated and stored by a previously selected program.
3. Landing Site Orientation (Option 00004)

\[
\begin{align*}
X_{SM} &= \text{Unit} (R_{LS}) \\
Y_{SM} &= \text{Unit} ((Z_{SM} \times X_{SM}) \\
Z_{SM} &= \text{Unit} (H_{CSM} \times X_{SM})
\end{align*}
\]

where:

- \( R_{LS} \) = The position vector of the LM on the lunar surface at a landing site and a time \( T(align) \) selected by the crew.
- \( H_{CSM} \) = The angular momentum vector of the CSM (Regi x Vesm).

A special case of the landing site orientation occurs when \( T(align) \) is defined as the time of lunar landing \( T(land) \). This case occurs only if \( T(land) \) has been defined by the MSFN, transmitted to the crew, and the crew has then defined \( T(align) \) to be \( T(land) \) in this program.

4. Nominal Orientation (Option 00002)

\[
\begin{align*}
X_{SM} &= \text{Unit} (R) \\
Y_{SM} &= \text{Unit} ((V \times R) \\
Z_{SM} &= \text{Unit} (X_{SM} \times Y_{SM})
\end{align*}
\]

where:

- \( R \) = The geocentric (earth orbit) or selenocentric (lunar orbit) radius vector at time \( T(align) \) selected by the astronaut.
- \( V \) = The inertial velocity vector at time \( T(align) \) selected by the astronaut.

5. REFSSMMAT (Option 00003). A known orientation stored in the LGC at a previous time.

Assumptions:

1. The configuration may be docked (LM/CSM) or undocked (LM alone). The present configuration should have been entered into the LGC by completion of the DAP Data Load routine (R03).
2. There are no restraints upon the LM attitude control modes until a PGNS controlled maneuver is called by a program or the crew wishes to manually maneuver the vehicle. The Guidance Control switch may be at PGNS or ACS and, if at PGNS, the mode may be Auto or Attitude Hold. Prior to PGNS controlled maneuvers the LGC will request the correct mode if it is not in effect. For manually controlled maneuvers the crew must select the correct modes.
3. This program makes no provision for an attitude maneuver to return the vehicle to a specified attitude. Such a maneuver, if desired, must be done manually. An option is provided however to allow pointing of the AOT at astronaut or LGC selected stars either manually by the crew or automatically by an LGC controlled attitude maneuver.
4. An option is provided to realign the IMU to the preferred, nominal, or landing site orientation without making celestial body sightings.
5. Extended verbs should not be exercised during this program because of possible interference with the AOT Mark routine (R53).

Sequence of Events:

V37E52E

Flash ID 00001 IMU Alignment Option 0000X
(1—Preferred, 2—nominal, 3—REFSSMMAT, 4—landing site)

V22E. Reload desired option.
For Cursor/Spiral Option

After V50N25 display first time, V52 ENTER

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V01N70</td>
<td>0CODE</td>
</tr>
</tbody>
</table>

C—AOT Detent
0—COAS calibration (not allowed), 1—front left, 2—front center, 3—front right, 4—right rear, 5—rear center, 6—rear left, 7—backup optical system—COAS

DE—Celestial Body Code
00—Planet, 01/46—star from code list, 46—sun, 47—earth, 50—moon.

V21E. Load desired star code.

V32E

Recycle to Flashing V01N70 display above.

V25E

Load desired vector components.

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V06N88</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

V25E

Load desired vector components.

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V06N70</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

Verify components of vector.

PRO

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V25/53</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

N71

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V06N88</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

To redefine star V32E to Flashing V01N71 display.

If this is the last mark defined, digit A = 1 in R2 or R3.

To change from V52 or V53 to opposite verb, ENTER.

For V52—Position Cursor, then press mark X, Mark Y, or ROD switch.

For V53—Position Spiral, then press Mark X, Mark Y, or ROD switch.

V32E

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V21/22</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

N70

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V21/22</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

N70

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>V06N79</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

To ratchack—PRO then V50N25 display with R1 00015 will appear and recycle through program.

To terminate—ENTER, V77E, No DAP Light OFF

V37

To recheck—PRO then V01N70 display with R1 00015 will appear and recycle through program.

To terminate—ENTER, V77E, No DAP Light OFF

Nominal values for N05 display

AOT: 2 stars ≤ | .12° |
: star and planet ≤ | .21° |

COAS: 2 stars ≤ | .71° |
: star and planet ≤ | .73° |
For Mark X, Mark Y Option

PRO

Flashing Code

V01N70 00CDE

PRO

C—AOT Detent
0—COAS calibration (not allowed), 1—front left,
2—front center, 3—front right, 4—right rear,
5—rear center, 6—rear left, 7—backup optical
system—COAS
DE—Celestial Body Code
00—Planet, 01/45—star from code list, 46—sun,
47—earth, 50—moon.

V21E. Load desired star code and detent.

PRO

If C = 7, COAS to be used.

Flashing Code

V08N87 00CDE

V24E. Load correct data.

PRO

Flashing Components of Celestial Body

V06N88

V26E. Load desired vector components.

PRO

Flashing Desired Automanipulator to FDAI

V50N18

PRO

Automanipulator or trim Guidance Control — PGNS

V50N25

PRO — Flashing V50N18 display returns after manual maneuver — Mode Control

(PGNS) — Attitude Hold

V76E — No DAP light on

PRO

To accept

Flashing Gyro Torquing Angles

V06N93

To torque

Mode Control (PGNS) — Attitude Hold

V76E — No DAP light on

PRO

Flashing Checklist Code

V06N20

To recheck — PRO then V06N20 display with R1 0015 will appear and recycle through program.

To terminate — ENTER, V77E, no DAP light of

OFF

Flashing Choose New Program

V37

Nominal values for Nom display

AOT: 2 stars < |.12° |

COAS: 2 stars < |.71° |

: star and planet < |.21° |

: sun and planet < |.73° |

For DE = 00 Celestial Body

Flashing Celestial Body Vector

V06N88

XXXXXXXX

XXXXXXXX

XXXXXXXX

XXXXXXXX

XXXXXXXX

XXXXXXXX

XXXXXXXX

XXXXXXXX
P57—LUNAR SURFACE ALIGN PROGRAM

Purpose:

1. While on the surface of the moon to align or realign the IMU to one of three types of orientations:
   a. Landing Site Orientation (Option 4)
      \[ X_{SM} = \text{Unit} (R_{LS}) \quad Y_{SM} = \text{Unit} (Z_{SM} \times X_{SM}) \quad Z_{SM} = \text{Unit} (H_{CSM} \times X_{SM}) \]
      where:
      - The origin is the center of the moon.
      - \( R_{LS} \) = The position vector of the LM on the lunar surface at the most recently designated landing site and a time \( T(\text{align}) \) selected by the crew.
      - \( H_{CSM} \) = The angular momentum vector of the CSM \( \times V_{CSM} \).
   b. Preferred Orientation (Option 1)
      An IMU orientation specified by the ground and loaded into the LGC by the LGC Update program (P27). When such an orientation is loaded by the ground the preferred orientation flag will also be set during P27.
   c. REFSSMAT (Option 3).

Assumptions:

1. There are several methods available to the crew for completing an IMU alignment. The resultant accuracy of the IMU to the specified desired orientation (that is, that orientation defined by the final REFSSMAT) is dependent upon the mode of alignment which the crew selects. This selection will be dictated by the circumstances at the time of alignment.

2. The LM has landed on the lunar surface. The LM yaw angle with respect to the inertial orientation of the IMU at landing was not constrained during landing.

3. All possible efforts have been made by the crew to assure that the LM will not shift its position with respect to the lunar surface. No provision has been made to incorporate in the LGC any measurement of LM settling on the lunar surface. However, a shifting of the LM will result in a misaligned IMU only in the case where an alignment is made from a stored LM attitude with respect to the lunar surface (Technique Codes 00000 and 00001) and the IMU is not subsequently aligned by reference to celestial bodies and/or lunar gravity.

4. The ISS is on and may be:
   a. At an inertial orientation "unknown" to the LGC; that is, having been shut down and restarted since landing without subsequent orientation determination.
   b. At an inertial orientation "known" by the LGC; that is, neither gimbal lock nor IMU power interruption has occurred since the last IMU alignment or orientation determination. Therefore the present orientation differs from that stored in REFSSMAT only due to gyro drift and/or the initial misalignment of the IMU to the stored REFSSMAT.

5. Extended verbs should not be exercised during the Lunar Surface Sighting Mark routine (R59) because of possible interference with the AOT Mark routine (R53).

6. The LM attitude with respect to the lunar surface is available in LGC storage; that is, it will have been stored by the Landing Confirmation program (P68). Once this attitude has been stored it will be preserved by the LGC until it is replaced by a more recent value.

7. This program is selected by the astronaut by DSKY entry. It will normally be selected to perform an alignment of the IMU immediately after landing on the lunar surface, prior to selection of the RR Lunar Surface Navigation program (P22), prior to ACS initialization, and approximately 15 minutes prior to ascent. This program may also be used to provide an IMU alignment in time-critical emergencies prior to ascent.

8. The DAP should be off during gyro torquing by this program to preclude RCS jet firings due to realignment of the IMU causing attitude errors exceeding the maximum deadband.

9. A determination of the LM position vector while on the lunar surface \( \mathbf{R}_{L} \) can be accomplished only in conjunction with IMU alignment Technique 2 (using AO sightings on two celestial bodies). It is valid only if the lunar gravity vector has been previously defined during P57, using IMU alignment Technique 1 (using REFSSMAT or stored LM attitude and determination of lunar gravity vector) or Technique 3 (using single celestial body sighting and determination of lunar gravity vector).

Sequence of Events:

V37E57E

Flashing Option Code ID 00001 Specify Alignment mode

Flashing Option Code 0000x

Option Code

0—preferred, 2—nominal (not valid)
3—REFSSMAT, 4—landing site

Flashing Time of Alignment

00XX.XX min 0XX.XX s

Flashing Specify Alignment Technique

00006 Alignment Technique

000X

0—prestored attitude, 1—prestored attitude +g, 2—two celestial bodies, 3—one celestial body +g

DataCode

00CD0

C=1—REFSSMAT defined
C=0—REFSSMAT not defined
D=1—stored LM attitude available
D=0—stored LM attitude not available

For alignment technique REFSSMAT +g or one celestial body +g.

Flashing Present ICDU Angle

OGA +042.00 deg

IGA +318.00 deg

MGA +035.26 deg

No Attitude and No DAP light on, then off twice.

Flashing Angle Between Present and Stored

V06N04 Gravity Vector

XXX.XX deg

For Alignment technique stored or REFSSMAT Attitude or two celestial bodies and IMU not aligned.

Flashing Desired ICDU Angles

OGA XXX.XX deg

IGA XXX.XX deg

MGA XXX.XX deg

LM-75

P57 (continued)

B. The DAP should be off during gyro torquing by this program to preclude RCS jet firings due to realignment of the IMU causing attitude errors exceeding the maximum deadband.

G. A determination of the LM position vector while on the lunar surface \( \mathbf{R}_{L} \) can be accomplished only in conjunction with IMU alignment Technique 2 (using AO sightings on two celestial bodies). It is valid only if the lunar gravity vector has been previously defined during P57, using IMU alignment Technique 1 (using REFSSMAT or stored LM attitude and determination of lunar gravity vector) or Technique 3 (using single celestial body sighting and determination of lunar gravity vector).
For alignment techniques
Two celestial bodies or one celestial body +g and IMU aligned.

Flash V01N70

C—AOT Detent
0—COAS calibration (not allowed), 1—front left
2—front center, 3—front right, 4—right rear,
5—rear center, 6—rear left, 7—backup optical
system — COAS

DE—Celestial Body Code
00—planet, 01/45—star from star code list,
46—sun, 47—earth, 50—moon.

V21E. Load desired star code and detent.
For DE = 00
Flash Components of Celestial Body Unit X .XXXXXX
Vector Y .XXXXXX
Z .XXXXXX

V32E

PRO
Flash Cursor Angle V05N79 XXX.XX deg
Position Code 0000X

V32E (To redefine star)
Flash (Same as above V01N70.) 000DE

or

PRO
Flash Code V01N71 000DE

PRO
Flash V52N71 Code 000DE
V53N71 Spiral Counter XXXXX

To change V52N71 to V53N71 or vice versa, key ENTER.
For Verb 52, position Cursor, and punch Mark X, Mark Y or click ROD switch.
For Verb 53, position Spiral and punch Mark X, Mark Y, or click ROD switch.

Last mark defined by digit A = 1 in R2 or R3.
Flash Load Cursor or Spiral Angle Data V21/V22 in R1 or R2 as Requested by
N79 XXX.XX deg
V21/V22 0000X
Position Code

V21 — Cursor Data R1
V22 — Spiral Data R2

**Purpose:**
1. To calculate the required time of DPS ignition (TIG) and other initial conditions
required by the LGC for a PGNS-controlled, DPS-executed, braking phase of the
powered landing maneuver.
2. To provide option to fine align the IMU to an existing REFSMMAT.
3. To align the LM to the thrusting ignition attitude.
4. To control the PGNS during countdown, ignition, and thrusting of the powered
landing maneuver until HI gate.
5. To indicate to the crew that HI gate has been reached by automatic selection of the
Approach Phase program (P64).

**Assumptions:**
1. The LM is on a descent coast orbit (Hohmann transfer) approaching the braking
ignition point which is nominally 50,000 feet above the lunar radius at the
designated landing site. The descent coast orbit is approximately co-planar with the
CSM orbital plane. If the designated landing site is not in the descent coast plane at
the nominal time of landing the plane change will be accomplished by the powered
landing maneuver (Braking program P63, and Approach program P64).
2. The CSM is in a near-circular orbit around the moon at a nominal altitude of 60
nautical miles. The CSM is maintaining a preferred tracking attitude for optical
tracking of the LM.
3. The IMU is on and aligned to a landing site orientation defined for the designated
landing site and the nominal time of landing [T(land)], but should be fine aligned to
this orientation as closely as possible prior to DPS ignition. The LM has not yet been
aligned to the correct attitude for ignition for the powered landing maneuver.
4. The Landing Radar (LR) was energized, checked out, and made ready at LR Position No. 1 prior to selection of this program. Radar data will not be incorporated into the LM state vector until the astronaut sets the LR permit flag via V25E, indicating he is satisfied with the quality of the data. V25E will reset the LR permit flag.

5. The Landing Analog Displays routine (R10) is enabled 2 seconds after Average G is enabled and is terminated upon termination of Average G.

6. The entire powered landing maneuver (braking, approach, and landing) will be accomplished using the DPS engine.

7. The aim conditions for braking phase are stored in the LGC.

8. The following parameters required by this program have been stored by the LGC since LGC initialization by erasable load:
   a. The LM and CSM state vectors. The LGC has updated these as required. No further state vector updates from any external source other than the LR will be accepted by this program.
   b. The nominal landing site time at the designated landing site T(land) and the position RLs: Corrections to the landing site position RLs may be made by keying V21 through V26 N69 and entering the appropriate correction.

9. The DPS is not throttleable over the whole range (0 to maximum). It must be operated either at maximum throttle or over a specific throttle range of lower settings. These throttle settings are total throttle settings, that is, the sum of the manual setting (whose minimum is about 10 percent) and the PGNS commanded setting.

   This program assumes the Throttle Control switch to be in Auto (the DPS receives the sum of the manual and PGNS commanded settings) and the manual throttle to be set at minimum for ZOOMTIME seconds of thrusting, and thereafter at a level less than that required by the LGC. The value ZOOMTIME is in erasable storage, having been loaded prior to launch or by P27.

   Due to the region of forbidden throttling, thrust command logic in conjunction with the interlock terminal conditions assures that the commanded throttle remains at maximum until the guidance equations first require it to be within the allowable throttle range. Therefore it should remain within the allowable throttle range.

   Furthermore, the DPS must be started in the following sequence: (1) +X axis 2-jet ullage for 7.5 seconds, (2) ignition at minimum throttle, (3) ullage off 0.5 seconds after ignition, (4) ZOOMTIME seconds at minimum thrust, and (5) maximum until the guidance equations first require it to be within the allowable throttle range.

   The X-axis override option provides the crew with the ability to exercise manual control about the LM X axis with the attitude controller even though the PGNS Mode Control switch is in Auto. When the controller is returned to detent the PGNS damps the yaw rate, stores the yaw attitude when the yaw is damped, and then maintains that attitude.

   The X-axis override option is available to the crew (until the estimated altitude is below 30,000 feet); however, it should not be exercised when the LGC is specifying a desired yaw attitude; that is, during the attitude maneuver to the thrusting attitude. The option is inhibited by this program from midway in the program to the end.

12. The LGC specifies LM attitude during the powered landing maneuver based upon the requirements of thrust vector control, landing site visibility, and LR orientation.

   After DPS ignition, thrust vector control is required through the remainder of this program. The landing site becomes visible at the beginning of the approach phase.

   The first restraint upon the LM yaw attitude to occur is that of LR orientation. The LGC will not attempt to use LR data until the LGC estimation of altitude is 50,000 feet. Automatic X-axis override lockout and yaw attitude specification by the LGC will not occur until the LGC estimated altitude is 30,000 feet. Before this time, the astronaut must maneuver to a roughly-window-up yaw orientation to prevent subsequent loss of S-band lock-on. The LGC will then command the vehicle to the LGC-specified yaw attitude.

   Subsequent to X-axis override lockout, control of the vehicle about the LM X axis is governed by LR orientation requirements during this program. The landing site becomes visible to the command pilot if the "look" angle (the angle between the LM -X axis and the LOS to the landing site) is greater than 25 degrees and the LOS is in or near the LM X/Z plane.

   At any time during P63 or P64, the magnitude of the look angle and the orientation of the look angle plane (that plane containing the LOS and the LM X axis) is defined by the inertial orientation of the LM X axis and the position of the LM with respect to the landing site.

13. The crew has the capability to display LGC calculated values of forward velocity, lateral velocity, altitude, and altitude rate on certain LM meters during this program. The calculations of these parameters are under the control of the Landing Analog Displays routine.

14. The crew can select a display of the LGC computed throttle setting by keying V16 N92E.
15. The Rate of Descent (ROD) mode is not enabled during this program.

16. An abort from the lunar descent may be required at any time during the descent orbit injection, the descent coast, or the powered descent (P63, P64, or P66).

For aborts after DPS ignition for the powered landing maneuver, time is critical. During this period an abort is nominally commanded by pushing one of two buttons in the LM. The abort may be commanded to use the descent stage (Abort button) or the ascents stage (Abort Stage button). If the descent stage is selected, and the DPS propellant approaches exhaustion, control must be switched to the ascent stage by the crew by ascent stage selection (Abort Stage button).

During the powered landing maneuver, the LGC will continuously monitor the Abort and Abort Stage discretes, and upon receipt of either will terminate the orbit injection, the descent coast, or the powered descent (P63, P64), or (P66). Both abort programs will guide the LM to an acceptable orbit.

The monitor of the Abort and Abort Stage buttons is controlled by the Abort Discretes Monitor routine (R11) which will be enabled by this program.

This step can be locked out by setting the CHANBKP location (9374) in the computer to 000X.1g. This location can only be changed by Fresh Start or Restart. The location is R2 of N46 which is used in the DAP Data Load Routine (V48).

17. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Auto, the PGNS controls the total vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about only the yaw axis with the ACA (X-axis override) provided the X-axis override capability is permitted.

If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS holds the vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about all vehicle axes with the ACA using either the Rate Command or Minimum Impulse mode. However, it is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.

During a thrusting maneuver in the PGNS/Attitude Hold mode the astronaut is responsible for maintaining small enough attitude errors to achieve guidance objectives.

18. Control of LM DPS, RCS, and APS is transferred from PGNS to the Abort Guidance System (AGS) by changing the Guidance Control switch from PGNS to AGS.

The AGS will be capable of taking over control of the LM during any portion of the lunar descent or ascent or during either of the abort programs (P70 or P71). The AGS will guide the LM to a safe orbit.

The AGS may be initialized by the LGC at any time by manual selection of the AGS Initialization routine (R47).

In the event that the Guidance Control switch is changed from PGNS to AGS during a thrusting maneuver, the LGC will continue computation of position and velocity, the desired thrust vector, and the desired attitude errors.

19. The PGNS generates two types of errors for display on the FDAI as selected by the astronaut.
   a. Mode 1—Selected by Verb 61. Autopilot following errors used as a monitor of the DAP's ability to track automatic steering commands.
   b. Mode 2—Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.

Display selection is always based upon last entry mode in the DSKY or Mode 2 by the Attitude Maneuver Routine R60.

20. The event timer was set prior to selection of this program to count to zero at T BRAK based on a time from ignition provided by the ground.

21. The Load DAP Data routine (R03) has been performed prior to selection of this program. At that time the DPS engine gimbal should have been driven to the correct trim position.

22. During DPS burn only, the pitch-roll RCS jets autopilot (U and V jets) may be disabled (V65E) or enabled (V75) by Extended Verb as shown. This capability is intended to be used to prevent LM and descent stage thermal constraint violations during CSM-docked DPS burns (P40). The capability exists during P70 also. Performance of FRESH START (V36E) will always enable the pitch-roll jets.

23. This program is selected by the astronaut by DSKY entry. It should be selected at least 20 minutes before the nominal time of ignition for the powered landing maneuver (T BRAK).

24. Engine ignition may be slipped beyond the established TIG if desired by the crew or if state vector integration cannot be completed in time.

25. Two alarm conditions may be originated by the PGNS powered landing equations:
   a. If subroutine ROOPTNPS in the RG/VG calculation fails to converge in 8 passes the LGC will turn on the Program Alarm light, store Alarm Code 1406, and go immediately to the final Automatic Request routine (R00). This alarm can occur only in P63 or P64.
   b. If an overflow occurs anywhere in the landing equations the LGC will turn on the Program Alarm light, store Alarm Code 1410, stop all vehicle attitude rates, and continue. This alarm can occur only in P63, P64, or P66.

26. This program allows manual control of LM attitude and the selection of P66.

During P63 (P64) the astronaut can display the PGNS total guidance error on the FDAI error needles (Attitude Monitor switch in PGNS) by having keyed in V62E through the DSKY. He can then steer out the PGNS P63 attitude errors with the PGNS manually (Guidance Control switch in Attitude Hold); or automatically (PGNS Mode Control switch in Attitude Hold); or with the AGS manually (Guidance Control switch in AGS and the AGS Mode Control switch in Attitude Hold).

NOTES: If the astronaut hits the ROD (Rate of Descent) switch while the PGNS Mode Control switch is in Attitude Hold, the LGC will irrevocably transfer him out of the automatic guidance program mode (P63 and P64) into the ROD program (P66).

Sequence of Events:

V37E63E  Flashing  Time to Go in Braking Phase  XXbXX min/s
V06N61  Time from Ignition  XXbXX min/s
N33E  Time of Ignition  000XX.h
V06N33  Cross Range Distance  XXXX.X xmi

KEY REL
Purpose:
1. To control the PGNS during the thrusting of the powered landing maneuver between HI gate and LO gate.
2. To control the DPS thrust and attitude between HI gate and LO gate.
3. To provide the crew with the capability of redesignating the landing site to which the PGNS is guiding the LM.

Assumptions:
1. The LM is on the powered landing descent between HI gate and LO gate.
2. The CSM is in a near circular orbit around the moon at a nominal altitude of 60 nautical miles. The CSM is maintaining a preferred tracking attitude for optical tracking of the LM.
3. The Landing Radar (LR) is on, checked out, and should provide to the LGC velocity and range information with respect to the moon. This information should have been incorporated into the LM state vector. The LGC/LR operation is under the control of the descent state vector update routine (R12) which is already in process.
4. The entire powered landing maneuver (braking, approach, and landing) will be accomplished using the DPS engine.
5. The aim conditions (LO gate) for the approach phase are stored in the LGC.
6. The LM state vector has been stored in the LGC since initialization by ERASABLE register load. The LGC has updated this as required during thrusting. No further state vector updates from any source other than the LR will be accepted by this program.
7. The DPS is not throttled over the whole range from 0 to maximum. It must be operated either at maximum throttle or over a specific throttle range of lower settings. These throttle settings are total throttle settings that is, the sum of the manual setting (whose minimum is about 10 percent) and the PGNS commanded setting.

This program assumes the Throttle Control switch to be in Auto (the DPS receives the sum of the manual and PGNS commanded settings) and the manual throttle to be set at a level less than that required by the LGC.

Namely, if the Approach Phase program is completed without any redesignation of the landing site (see Assumption 10), the throttle will remain within the allowable throttle range throughout the phase. Excessive target redesignations during this program, however, may result in required throttle excursions outside the allowable range. In such cases the LGC will command maximum throttle for at least 2 seconds, and until the required throttle setting returns to the permitted throttle region.

8. During the powered landing maneuver, the LGC will monitor the presence or absence of the Auto Stabilization discrete. This discrete is issued to the LGC when the Mode Control switch is in the Auto position.

The LGC will also monitor the presence or absence of the Auto Throttle discrete. This discrete is issued to the LGC when the Thrust Control switch is in the Auto position.

Should either of these discretes be interrupted during the powered landing maneuver, the LGC assumes that it no longer has complete automatic control of the maneuver.

The monitor and the associated LGC logic is included in the Landing Auto Modes Monitor routine (R13) which is already in process.

The LGC can be forced to ignore the absence of the Auto Throttle discrete and continue issuing normal throttle commands by setting the CHANBPK routine (3074) in the computer to 0001Xg. This location can only be set by ground loading and is not changed by Fresh Start or Restart. This location is R2 of N40 used in the DAP Data Load Routine (R48).

9. The X-axis override option is not provided to the crew whenever the LGC estimated attitude is below 30,000 feet.
10. During most of the approach phase, the LGC provides the crew with the option to redesignate the landing site to which the LM is going using the LPD mode. This option is called the Landing Point Designator (LPD) mode. The PGNS Mode Control switch must be in Auto for the ACA to function as a landing site redesignator.

The landing point redesignation, if exercised, is based on visual assessment of the landing site with respect to the presently designated landing site. During the LPD mode, the present landing site is displayed on the DSKY in terms of coordinates on the LPD sight grid on the left hand LM window (LPD angle). Landing site redesignations are manually input into the computer via the attitude controller on an incremental basis; that is, a limit switch actuation in the attitude controller causes the LGC to redesignate the landing site at a fixed angular increment (1 degree in elevation, 1 degree in azimuth) from the present LM landing site. The applicable controller polarities are:

a. Pitch Rotation gives LPD Elevation (new site beyond present site).
b. +Pitch Rotation gives LPD Elevation (new site short of present site).
c. Roll Rotation gives LPD Azimuth (new site right of present site).
d. -Roll Rotation gives LPD Azimuth (new site left of present site).

11. The initial maneuver of the approach phase is the LM attitude transition from the LM attitude at the start of P64 to a satisfactory attitude for landing site visibility. After the completion of this maneuver, the LM attitude is constrained by thrust pointing requirements and is controlled about the thrust axis so as to maintain the current landing site in the LM X-Z plane. The conditions achieved at the start of P64 should be such that the thrust pointing requirements of the approach phase will yield satisfactory visibility and radar orientations.

The landing site becomes visible to the command pilot if the "look" angle (the angle between the X LM axis and the LOS to the landing site) is greater than 25 degrees and the LOS is in or near the LM X-Z plane. At any time during P63 or P64, the magnitude of the look angle and the orientation of the look angle plane (plane containing the LOS and the LM X axis) are defined by the inertial orientation of the LM X axis and the position of the LM with respect to the landing site.

The inertial orientation of the LM X axis is controlled by requirements of thrust vector control. The orientation of the LM windows with respect to the look angle plane is controlled by rotation of the vehicle about the LM X axis.

12. The crew has the capability to display LGC calculated values of forward velocity, lateral velocity, altitude, and attitude rate on certain LM meters during this program. The calculation of these parameters is under control of the Landing Analog Display routine which is already in process.

13. The Rate of Descent (ROD) mode is not enabled during this program.

14. An abort from the lunar descent may be required at any time during the descent orbit injection, the descent coast, or the powered descent (P63), (P64), or (P66). For aborts after DPS ignition for the powered landing maneuver, time is critical. During this period an abort is normally commanded by pushing one of two buttons in the LM. The abort may be commanded to use the descent stage (Abort button) or the ascent stage (Abort Stage button). If the descent stage is selected, and the DPS propellant approaches exhaustion, control must be switched to the ascent stage by the crew via ascent stage selection (Abort Stage button). During the powered landing maneuver the LGC will continuously monitor the Abort and the Abort Stage discrete, and upon receipt of either will terminate the program in process and call the appropriate abort program (DFP Abort program (P70) or APS Abort program (P71)). Both abort programs will guide the LM to an acceptable orbit.

Monitoring the Abort and Abort Stage buttons is controlled by the Abort Discrete Monitor routine (R11) which is already in process.

This step can be locked out by setting the CHANBKUP location (0374) in the computer to 000X1g. This location can only be set by astronaut or ground loading and is not changed by Fresh Start or Restart. This location is R2 of N46 which is used in the DAP Data Load Routine (V48).

15. If a thrusting maneuver is performed with the Guidance Control switch in PGN5 and the Mode Control switch in Auto, the PGN5 controls the total vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about only the yaw axis with the ACA (X-axis override) provided the X-axis override capability is permitted.

If a thrusting maneuver is performed with the Guidance Control switch in PGN5 and the Mode Control switch in Attitude Hold, the PGN5 holds the vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise manual control about all vehicle axes with the ACA using either the Rate Command or Minimum Impulse mode. However, it is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.

16. Control of the LM DAP, RCS, and APS is transferred from the PGN5 to the Abort Guidance System (AGS) by placing the Guidance Control switch from PGN5 to AGS.

The AGS will be capable of taking over control of the LM during any portion of the lunar descent or ascent or during either of the abort programs (P70 or P71). The AGS will guide the LM to a safe orbit.

The AGS may be initialized by the LGC at any time during this program by manual selection of the AGS Initialization routine (R47).

In the event that the Guidance Control switch is changed from PGN5 to AGS during a thrusting maneuver, the LGC will continue computation of position and velocity, the desired thrust vector, and the desired attitude errors. However, the PGN5 will not be responsible if register overflows occur within the LGC.

17. The PGN5 generates two types of errors for display on the FDAI as selected by the astronaut:

a. Mode 1—Selected by Verb 61. Autopilot following errors are used as a monitor of the DAP's ability to track automatic steering commands.
b. Mode 2—Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.

18. The Load DAP Data routine (R03) has been performed prior to the start of the powered landing maneuver and should not be required during this program.

19. This program is automatically selected by the Braking Phase program (P63) at the completion of the P63 aim conditions.

20. Two alarm conditions may be originated by the PGN5 powered landing equations:

a. If Subroutine ROOTPERS in the RG/VG calculation fails to converge in 8 passes the LGC will turn on the Program Alarm light, store Alarm Code 1406, and go immediately to the Final Automatic Request routine (R00). This alarm can occur only in P63 or P64.
b. If an overflow occurs anywhere in the landing equations the LGC will turn on the Program Alarm light, store Alarm Code 1410, and go immediately to the Final Automatic Request routine (R00). This alarm can occur only in P63 or P64.

21. This program allows manual control of the LM attitude. If manual control is desired, put the PGN5 Mode Control switch in Attitude Hold and use the LGC to control the LM attitude.

If P65 is desired, click the ROD switch while the PGN5 Mode Control switch is in Attitude Hold. The LGC may not redesignate the landing site while the Mode Control switch is in Attitude Hold. To use the ACA to redesignate the landing site, put the Mode Control in Auto and rotate the ACA in the desired direction.

NOTE: Landing Site Redesignation must be completed before P66 is selected because P64 cannot be reentered once it has been exited.

22. The crew can select a display of the LGC computed throttle setting by keying V16 N92E.
**Sequence of Events:**

**Flashing**
- Time Left for Redesignations/LPD Angle
- Altitude Rate
- Computed Altitude

**Manual Throttle Control**
- TTCA — Advance until thrust = 10%, throttle control — MAN

**V16N92E**
- Percent of Full Thrust (10,500 lb)
- Altitude Rate
- Computed Altitude

**To return to auto throttle**
- Throttle Control — AUTO
- TTCA — minimum position

**KEY REL**
- Same display as above.

**Manual Attitude Check**
- Mode Control (PGNS — Attitude Hold)
- To use Landing Point designator
- Verify Mode Control PGNS — AUTO

**PRO**
- Time Left for Redesignations/LPD Angle
- Altitude Rate
- Computed Altitude

Redesignate landing site as described (+ pitch redesignates landing site toward LM by 1 degree; + roll redesignates new site to right of present site by 1 degree in azimuth.) V06N64 changes the elevation LPD angle accordingly.

**LM State Vector**
- No further state vector updates from any source other than the LR will be accepted by the LGC.

**Throttle Control**
- The DPS is not throttleable over the whole range from 0 percent to maximum. It must be operated either at maximum throttle or at specific throttle settings. These throttle settings are total throttle settings; that is, the sum of the manual setting (whose minimum is 10 percent) and the PGNS commanded setting.

**Assumptions:**
1. The LM is in the late stages of landing, with a low inertial velocity.
2. The Landing Radar (LR) is on, checked out, and providing to the LGC velocity and range information with respect to the moon. This information has been incorporated into the LM State Vector. The LGC/LR operation is under the control of the Descent State Vector Update routine (R12) which is already in process.
3. The entire powered landing maneuver (braking, approach, and landing) will be accomplished using the DPS engine.
4. The LM State Vector has been stored in the LGC since initialization by the LR. The LGC has updated this as required during thrusting. No further updates from other sources will be accepted by this program.
5. The DPS is not throttleable over the whole range from 0 percent to maximum. It must be operated either at maximum throttle or at specific throttle settings. These throttle settings are total throttle settings; that is, the sum of the manual setting (whose minimum is 10 percent) and the PGNS commanded setting.
6. The DPS is not throttleable over the whole range from 0 percent to maximum. It must be operated either at maximum throttle or at specific throttle settings. These throttle settings are total throttle settings; that is, the sum of the manual setting (whose minimum is 10 percent) and the PGNS commanded setting.
7. The entire powered landing maneuver (braking, approach, and landing) will be accomplished using the DPS engine.
8. The LGC will monitor the presence or absence of the Auto Stabilization discrete. This discrete is issued to the LGC when the Auto Stabilization mode is in use.
9. The Auto Stabilization mode, the PGNS will operate to null the forward and lateral surface velocities by controlling the inertial attitude of the spacecraft.
10. In the Attitude Hold mode, the LGC will hold an inertial attitude. However, the attitude may be changed by manual control via the attitude controller.

**Switch Operation:**
- Switch operation is on an incremental basis: - (increase ROD) or + (decrease ROD).
- Each command results in an LGC-commanded change of "ROD SCALE" in LM rate of descent.
- ROD SCALE is a value loaded into erasable storage prior to flight.

**An abort from the lunar descent may be required at any time during descent coast or powered descent (P63, P64, or P66).**
For aborts after DPS ignition for the powered landing maneuver, time is critical. During this period an abort is commanded by pushing one of two buttons in the LM. The abort may be commanded to use the descent stage (Abort button) or the ascent stage (Abort Stage button). If the descent stage is selected, and the DPS propellant approaches exhaustion, control must be switched to the ascent stage by the crew by ascent stage selection (Abort Stage button).

During the powered landing maneuver, the LGC will continuously monitor the Abort and Abort Stage discretes, and upon receipt of either will terminate the program in process and call the appropriate abort program (DPS Abort program (P70) or APS Abort program (P71)). Both abort programs will guide the LM to an acceptable orbit.

Monitoring the Abort and Abort Stage buttons is controlled by the Abort Discretes Monitor routine (R11) which is already in process.

This step can be locked out by setting the CHANBKUP location (0374) in the computer to 000X1g. This location can only be set by astronaut or ground loading and is not changed by Fresh Start or Restart. This location is R2 of N46 used during DAP Data Load Routine (V48).

11. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS will hold the vehicle attitude and will generate either Mode 1 or Mode 2 attitude errors for display on the FDAO. The crew may exercise manual attitude control about all vehicle axes with the ACA in either the Rate Command or Minimum Impulse mode. It is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.

The LGC is not permitted to compute body rates via V60 during this program. The attitude will always be available for astronaut display so that they are aware of the impending S/C motion when switching from Attitude Hold to Auto.

12. Control of the LM DPS, RCS, and APS is transferred from the PGNS to the Abort Guidance System (AGS) by placing the Guidance Control switch from PGNS to AGS.

The AGS will be capable of taking over control of the LM during any portion of the lunar descent or ascent or during either of the abort programs (P70 or P71). The AGS will guide the LM to a safe orbit.

The AGS may be initialized by the LGC at any time by manual selection of the AGS Initialization routine (R47).

In the event the Guidance Control switch is changed from PGNS to AGS during a thrusting maneuver, the LGC will continue computation of position and velocity, the desired thrust vector, and the desired attitude errors; however, the PGNS will not be responsible if register overflows occur within the LGC.

13. The Load DAP Data routine (R03) has been performed prior to the start of the powered landing maneuver and should not be required during this program.

14. This program is automatically selected by the Landing Auto Modes Monitor routine (R13) during the powered landing maneuver when:
   a. The targeted conditions for P64 are met (either automatically or astronaut flown)
   b. When the Rate of Descent (ROD) switch is activated by the astronaut after P63 throttle up in Attitude Hold.

Once this program has been selected it is no longer possible to return to the completely automatic powered landing programs (P63 or P64).

15. The crew has the capability to select a display of the LGC computed throttle setting by keying in V16N92E.
P68—LANDING CONFIRMATION PROGRAM

Purpose:
1. To terminate landing program and DAP functions.
2. To initialize the LGC for lunar surface operation.
3. To permit the astronaut to prevent RCS jet firings on the lunar surface.

Assumptions:
1. This program is selected by the astronaut by DSKY entry. It is to be selected only after the LM has landed on the lunar surface (Program P66).
2. V37E68E selection of P68 will terminate Average G and command the engine off (see P66).
3. The selection of this program places the DAP in the Minimum Impulse mode. As long as the astronaut keeps the mode control in Attitude Hold, RCS jet firings will not occur, even while the platform is being torqued (in P67).
4. This program will not shut off the DAP. However, the attitude errors are zeroed and the maximum deadband is set. No jet firings should result until one of the following occurs in sufficient magnitude to cause the attitude errors to exceed the deadband:
   a. The moon rotates,
   b. The LM shifts on the lunar surface,
   c. The IMU gyros are torqued for alignment by P57,
   d. The IMU drifts.
   The DAP may be shut off by setting the Mode Control-PGNS switch to Off.

Sequence of Events:
V37E68
Flashing Latitude XXX.XX deg (+ north) VOGN43 Longitude XXX.XX deg (+ east) Altitude XXXX.X nmi
PRO Mode Control (PGNS)—Attitude Hold, No DAP light on, Flashing Select New Program, v37

P70—DPS ABORT PROGRAM

Purpose:
1. To control a PGNS controlled DPS abort from the powered landing maneuver (P63, P64, or P65) when required.

Assumptions:
1. This program will control a DPS abort in one of two ways:
   a. If the altitude is greater than 25,000 feet, this program will command maximum DPS throttle, continue DPS thrusting, perform an attitude maneuver using the RCS to the correct attitude to continue the abort ascent, and complete the abort ascent to insert the LM into an abort orbit.
   b. If the altitude is less than 25,000 feet, this program will command maximum DPS throttle and enter a vertical rise phase which will terminate either when the LM altitude exceeds 25,000 feet or when LM velocity is greater than 40 ft/s.

During the vertical rise phase, the vehicle is maneuvered to align the LM +X axis with the local vertical (using the RCS), and the LM +Y axis normal to the anticipated pitch maneuvers plane. The program will then pitch the LM to the correct attitude for ascent and complete the abort ascent to insert the LM into an abort orbit.

9. Control of the LM DPS, RCS, and APS is transferred from the PGNS to the Abort Guidance System (AGS) by placing the Guidance Control switch from PGNS to AGS.

The AGS will be capable of taking over control of the LM during any portion of the lunar descent or ascent or during either of the abort programs (P70 or P71). The AGS will guide the LM to a safe orbit.

The AGS may be initialized by the LGC at any time by manual selection of the AGS Initialization routine (R47).

In the event that the Guidance Control switch is changed from PGNS to AGS during a thrusting maneuver, the LGC will continue computation of position and velocity, the desired thrust vector, and the desired attitude errors. However, the AGS will not be responsible if register overflows occur within the LGC.

10. The PGNS generates two types of errors for display on the FDAI as selected by the astronaut:
   a. Mode 1—Selected by Verb 61. Autopilot following errors used as a monitor of the DAP's ability to track automatic steering commands.
   b. Mode 2—Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.
11. The Load DAP Data routine (RO3) was completed prior to DPS ignition for the powered landing maneuver and should not be selected during this program.

12. During DPS burns only, the Pitch-Roll RCS jet autopilot (U and V jets) may be disabled (V65) or enabled (V75) by Extended Verb as shown. This capability is intended to be used to prevent LM and descent stage thermal constraint violations during CSM-docked DPS burns (P40). The capability exists during P63 also. Performance of FRESH START (V36E) will always enable the capability of the autopilot.

13. This program may be called in two ways:
   a. Abort button—If the Abort button is used during the powered descent it will be detected by the Abort Discretes Monitor routine (R11). R11 will then call this program.
   b. V37E 70E—This program may be called by the same procedure as other programs are manually called.

14. The LGC will not automatically select the APS Abort program (P71) if DPS fuel exhaustion occurs during execution of P70. The crew must anticipate DPS fuel exhaustion and select P71 by the Abort Stage button or by V37E 71E.

Sequence of Events:

**ABORT PUSH (DURING P63, P64, or P66)**

or

**V37E70E**

VO6N94 VGX (LM) (+Up) XXXX.X ft/s
Altitude Rate XXXX.X ft/s
Computed Altitude XXXXX. ft

To monitor Time-to-Go and cross range velocity.

**V16N77E**

V16N77 Time to Engine Cutoff X.X min/s
LM Velocity Normal to CSM Plane (VGY) XXXX.X ft/s
Absolute Value of Inertial Velocity XXXX.X ft/s

If burn is greater than 400 seconds, descent regulators close at PDI + 6:20. Then when VGY = 100 ft/s, shut down DPS engine. DES ENG CMD OVRD and ENG ARM are OFF. NULL components of V16N85 display.

**KEY REL**

Flashing VGX (LM) (+Up) XXXX.X ft/s
V16N84 Altitude Rate XXXX.X ft/s
Computed Altitude XXXXX. ft
ENG STOP - PUSH, ENG ARM - OFF, ABORT - Reset

**V82E** Display Orbital parameters.

Flashing V18V44 ApoCenter Altitude XXXX X nmi
Pericenter Altitude XXXX X nmi
Time from Interface Altitude X.XX min/s

**PRO**

Flashing V16N85 Same as above.

Flashing V37 Select New Program.

**LM-93**

**P71—APS ABORT PROGRAM**

**Purpose:**

1. To control a PGNS controlled APS abort from the powered landing maneuver (P63, P64, or P66) or a DPS Abort (P70) when required.

**Assumptions:**

1. The program will control an APS abort in one of two ways:
   a. If the altitude is greater than 25,000 feet, this program will ignite the APS, continue APS thrusting, perform an attitude maneuver (using the RCS) to the correct attitude to continue the abort ascent, and complete the abort ascent to insert the LM into an abort orbit.
   b. If the altitude is less than 25,000 feet, this program will ignite the APS, continue APS thrusting, enter a vertical rise phase which will terminate either when the LM altitude exceeds 25,000 feet or when LM vertical velocity exceeds 40 ft/s.

2. This program does not check to see if the DPS has been staged. Thus if P71 is selected via V37 and the descent stage has not been manually staged, this program may command engine on (Assumption 1.a or 1.b above). In such cases the command will go to the DPS.

3. The CSM is in a near circular orbit around the moon at a nominal altitude of 60 nautical miles. The CSM is maintaining a preferred tracking attitude for optical tracking of and RR tracking by the LM.

4. The Landing Radar (LR) is on and was checked out when in Position No. 1. The LGC/LR operation is under the control of the Descent State Vector Update routine (R12).

5. The Landing Analog Displays routine (R10) is enabled upon entry to this program, having been enabled by P63.

6. If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Auto, the PGNS controls the total vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise control about only the yaw axis with the ACA (X-axis override) provided the X-axis override capability is permitted.

If a thrusting maneuver is performed with the Guidance Control switch in PGNS and the Mode Control switch in Attitude Hold, the PGNS holds the vehicle attitude and generates either Mode 1 or Mode 2 attitude errors for display on the FDAI. The crew may exercise manual control about all vehicle axes with the ACA using either the Rate Command or Minimum Impulse mode. However, it is strongly recommended that powered flight not be attempted in the Minimum Impulse mode.
7. Control of the LM DPS, RCS, and APS is transferred from the PGNS to the Abort Guidance System (AGS) by placing the Guidance Control switch from PGNS to AGS. The AGS will be capable of taking over control of the LM during any portion of the lunar descent or ascent or during either of the abort programs (P70 or P71). The AGS will guide the LM to a safe orbit.

The AGS may be initialized by the LGC at any time by manual selection of the AGS Initialization routine (R47).

In the event that the Guidance Control switch is changed from PGNS to AGS during a thrusting maneuver, the LGC will continue computation of position and velocity, the desired thrust vector, and the desired attitude errors. However, the PGNS will not be responsible if register overflows occur within the LGC.

8. The PGNS generates two types of errors for display on the FDAI as selected by the astronaut.
   a. Mode 1—Selected by Verb 61. Autopilot following errors used as a monitor of the DAP's ability to track automatic steering commands.
   b. Mode 2—Selected by Verb 62. Total attitude errors used to assist the crew in manually maneuvering the vehicle.

9. The Load DAP Data routine (R03) was completed prior to DPS ignition for the powered landing maneuver and should not be selected during this program.

10. This program may be called in two ways:
    a. Abort Stage button—If the Abort Stage button is used during the powered descent or the DPS abort program (P70), it will be detected by the Abort Discretes Monitor routine (R11). R11 will then call this program.
    b. V37E71E—This program may be called by the same procedure as other programs are manually called.

Sequence of Events:
ABORT STAGE—Push (During P63, P64, P66, or P70) or V37E71E

V06N94 VGX (LM) (+ Up) XXXX.X ft/s
   Attitude Rate XXXX.X ft/s
   Computed Altitude XXXXX. ft

ENG START—Push, ENG ARM—ASC, RESET ENG STOP—on.

To monitor time to go and cross range velocity.
V16N77

V16N77 Time to Engine Cutoff XXXbXXX min/s
LM Velocity Normal to CSM Plane (VGY) XXXX.X ft/s
Absolute Value of Inertial Velocity XXXX.X ft/s

At VGX = 200 ft/s enable automatic shutdown ENG—ARM—OFF.
Null velocities with RCS using V16N85 displays.

P72—CSM COELPTIC SEQUENCE INITIATION (CSI) TARGETING PROGRAM

Purpose:
1. To calculate parameters associated with the following concentric flight plan maneuvers for CSM execution of the maneuvers under the control of the CMC: the Coelliptic Sequence Initiation (CSI) and the Constant Delta Altitude maneuver (CDH).

Assumptions:
1. At a selected TPI time the line of sight between the CSM and the LM is selected to be a prescribed angle (E) from the horizontal plane defined at the CSM position.
2. The time between CSI ignition and CDH ignition must be computed to be greater than 10 minutes for successful completion of the program.
3. The time between CDH ignition and TPI ignition must be computed to be greater than 10 minutes for successful completion of the program.
4. CDH Delta V is selected to minimize the variation of the altitude difference between the orbits.
5. CSI burn is defined such that the impulsive Delta V is in the CSM horizontal plane at GPS ignition.
6. The pericenter altitude of the orbit following CSI and CDH must be greater than 36,000 feet (lunar orbit) or 35 nmi (earth orbit) for successful completion of this program.
7. The CSI and CDH maneuvers are assumed to be parallel to the plane of the LM orbit, however crew modification of Delta V(LV) components may result in a change in the plane of the CSM maneuver.
8. The Rendezvous Radar may or may not be used to update the LM or CSM vectors for this program. If radar use is desired the radar was turned on and locked on the CSM by previous selection of P20. Radar sighting marks will be made automatically approximately once a minute when enabled. The rendezvous tracking mark counter is zeroed by the selection of P20 and after each thrusting maneuver.
9. The ISS need not be on to complete this program unless automatic state vector updating is desired by the Rendezvous Navigation program (P20). P20 will define the status of the ISS.

Sequence of Events:
This sequence of events is identical to P32. Record maneuvers and transmit to CSM.
P73—CSM CONSTANT DELTA ALTITUDE (CDH) TARGETING PROGRAM

Purpose:

1. To calculate parameters associated with the concentric flight plan maneuvers with the exception of Coelliptic Sequence Initiation (CSI) for CSM execution of the maneuvers under control of the CMC. The concentric flight plan maneuvers are the Coelliptic Sequence Initiation (CSI), the Constant Delta Altitude maneuver (CDH), the Transfer Phase Initiation (TP1), and the Transfer Phase Final (TPF) or braking maneuver.

Assumptions:

1. This program is based upon previous completion of the Coelliptic Sequence Initiation (CSI) Targeting program (P72). Therefore:
   a. At a selected TP1 time the line of sight between the CSM and the LM was selected to be a prescribed angle (E) from the horizontal plane defined at the CSM position.
   b. The time between CSI ignition and CDH ignition was computed to be greater than 10 minutes.
   c. The time between CDH ignition and TP1 ignition was computed to be greater than 10 minutes.
   d. The variation of the altitude difference between the orbits was minimized.
   e. CSI burn was defined such that the impulsive Delta V was in the CSM horizontal plane at CSI ignition.
   f. The pericenter altitudes of the orbits following CSI and CDH were computed to be greater than 35,000 feet (lunar orbit) or 85 nmi (earth orbit).
   g. The CSI and CDH maneuvers were assumed to be parallel to the plane of the LM orbit. However, crew modification of Delta V(LV) components may have resulted in an out-of-plane CSI maneuver.

Unless the inputs to this program are changed from those inserted in P72, the calculated parameters for the remaining maneuvers of the concentric flight plan will vary from those originally calculated and displayed only due to the continuous radar updating of the LM or CSM orbit.

2. The Rendezvous Radar may or may not be used to update the LM or CSM state vectors for this program. If radar use is desired the radar should be turned on and locked on the CSM by previous selection of P20. Radar sighting marks will be made automatically approximately once a minute when enabled. The rendezvous tracking mark counter is zeroed by the selection of P20 and after each thrusting maneuver.

3. The ISS need not be on to complete this program unless automatic state vector updating is required by the Rendezvous Navigation program (P20). If selected, P20 will define the status of the ISS.

Sequence of Events:

This sequence of events is identical to P33. Record maneuver parameters and transmit to CSM.

P74—CSM TRANSFER PHASE INITIATION (TP1) TARGETING PROGRAM

Purpose:

1. To calculate the required Delta V and other initial conditions required by the CMC for CSM execution of the Transfer Phase Initiation (TP1) maneuver. Given:
   a. Time of ignition (TIG(TPI)) or the elevation angle (E) of the CSM/LM LOS at TIG(TPI).
   b. Central angle of transfer (CENTANG) from TIG(TPI) to intercept time.

Assumptions:

1. This program is based upon previous completion of the Constant Delta Altitude (CDH) Targeting program (P73). Therefore:
   a. At a selected TP1 time (now in storage) the line of sight between the CSM and the LM was selected to be a prescribed angle (E) (now in storage) from the horizontal plane defined at the CSM position.
   b. The time between CDH ignition and TP1 ignition was computed to be greater than 10 minutes.
   c. The variation of the altitude difference between the orbits was minimized.
   d. The pericenter altitudes of the orbits following CSI and CDH were computed to be greater than 35,000 feet (lunar orbit) or 85 nmi (earth orbit).
   e. The CSI and CDH maneuvers were assumed to be parallel to the plane of the LM orbit. However, crew modification of Delta V(LV) components may have resulted in an out-of-plane CDH maneuver.

Unless the inputs to this program are changed from those inserted in P72 and/or P73, the calculated parameters for the remaining maneuvers of the concentric flight plan will vary from those originally calculated and displayed only due to the continuous radar updating of the LM or CSM orbit.

2. The Rendezvous Radar may or may not be used to update the LM or CSM state vectors for this program. If radar use is desired the radar should be turned on and locked on the CSM by previous selection of P20. Radar sighting marks will be made automatically approximately once a minute when enabled. The rendezvous tracking mark counter is zeroed by the selection of P20 and after each thrusting maneuver.

3. There is no requirement for ISS operation during this program unless automatic state vector updating is desired by the Rendezvous Navigation program (P20). If selected, P20 will define the status of the ISS.

4. Once the parameters required for computation of the maneuver have been completely specified, the value of the active vehicle central angle of transfer is computed and stored. This number will be available for display to the astronaut through the use of V06 N52.

The astronaut would call this display to verify that the central angle of transfer of the active vehicle is not within 170 to 190 degrees. If the angle is within this zone, the astronaut should reenter the input targeting parameters based upon Delta V and expected maneuver time.

Sequence of Events:

This sequence of events is identical to P34. Record maneuver parameters and transmit to CSM.
L-98  
P75—CSM TRANSFER PHASE MIDCOURSE (TPM) TARGETING PROGRAM

Purpose:
1. To calculate the required Delta V and other initial conditions required by the CMC for CSM execution of the next midcourse correction of the transfer phase of an active CSM rendezvous.

Assumptions:
1. There is no requirement for ISS operating during this program, unless automatic state vector updating is desired by the Rendezvous Navigation program (P20). If selected, P20 will define the status of the ISS.
2. The Rendezvous Radar is on and is locked on the CSM. This was done during previous selection of P20. Radar sighting marks will be made automatically approximately once a minute when enabled. The rendezvous tracking mark counter is zeroed by the selection of P20 and after each thrusting maneuver.
3. The time of intercept (T(INT)) was defined by previous completion of the Transfer Phase Initiation (TP1) Targeting program (P74) and is presently available in LGC storage.
4. Once the parameters required for computation of the maneuver have been completely specified, the value of the active vehicle central angle of transfer is computed and stored. This number will be available for display to the astronaut through the use of V06 N52.

The astronaut would call this display to verify that the central angle of transfer of the active vehicle is not within 170 to 190 degrees. If the angle is within this zone the astronaut should reassess the input targeting parameters based upon Delta V and expected maneuver time.

Sequence of Events:
This sequence is identical to P35 sequence. Record maneuver parameters and transmit to CSM.

P75/P77 CSM/LM State Vector Update Program

Purposes:
1. To provide a means of notifying the LGC that the CSM/LM has changed its orbital parameters by the execution of a thrusting maneuver.
2. To provide to the LGC the Delta V applied to the CSM/LM to enable an updating of the CSM or LM state vector.

Assumptions:
1. The LM crew has the Delta V to be applied to the CSM/LM in local vertical axes at the specified TIG. These values are displayed prior to TIG by the thrusting programs. No provision is made in these thrusting programs to display results of the maneuver in a form usable by this program.
2. If the Rendezvous Navigation program (P20) or the Lunar Surface Navigation program (P22) is in process this program must be selected prior to the CSM thrusting maneuver. This can be assured by voice communication between the LM and CSM.

Sequence of Events:
(Via uplink)
V30E P99 in mode light
Flashing Desired Automaneuver FDL Angle = R XXX.XX deg
time V50N18, P XXX.XX deg
Y XXX.XX deg

V33E (Proceed) for trim
or:
ENTER For no trim
V06N40 Time from Ignition XXX.XX min/s
Velocity to be Gained XXX.XX ft/s

TFI counts down until TIG -35 seconds when DSKY blanks for 5 seconds. V06N40 display returns.

At TIG ullage begins
At cutoff ullage stops
Flashing Time from Ignition XXX.XX min/s
Velocity to be Gained XXX.XX ft/s

V33E (Proceed)
Flashing V16N40 Velocity to be Gained

V33E (Proceed)
Flashing V16N45 Velocity to be Gained

V33E (Proceed)
Flashing V37

00E Go to Program P00

L-98  
P99—GUIDED RCS BURN (ERASABLE MEMORY PROGRAM)

Purpose:
1. To provide for a guided RCS burn that will be used to deorbit the LM ascent stage into a precise moon impact.

Assumptions:
1. The LM is the ascent stage only.
2. The erasable program for P99 has been previously uplinked and loaded into the computer.
3. A targeting program (P30—External Delta V Program or similar) has been performed prior to calling P99 for use.
4. The digital autopilot has been properly configured with a 5-degree deadband and correct ascent weight prior to use of this program.
5. The control of the spacecraft is PGNS in Auto with the Ascent Engine Arm switch at Off.
6. No more IMU alignment changes are allowed because the program overlays the AOT Mark and landing radar pad loads in EBANK.7.

Sequence of Events:
(Via uplink)
V30E P99 in mode light
Flashing Desired Automaneuver FDL Angle = R XXX.XX deg

V33E (Proceed) for trim
or:
ENTER For no trim
V06N40 Time from Ignition XXX.XX min/s
Velocity to be Gained XXX.XX ft/s

TFI counts down until TIG -35 seconds when DSKY blanks for 5 seconds. V06N40 display returns.

At TIG ullage begins
At cutoff ullage stops
Flashing Time from Ignition XXX.XX min/s
Velocity to be Gained XXX.XX ft/s

V33E (Proceed)
Flashing V16N40 Velocity to be Gained

V33E (Proceed)
Flashing V16N45 Velocity to be Gained

V33E (Proceed)
Flashing V37

00E Go to Program P00
LEP 001 (EMP 102) Cause a Software Restart Using V31 Request for Waitlist. This procedure allows a software restart to be placed in the WAITLIST and used when needed or desired.

LEP 002 (EMP 100) An Erasable Memory Program to Allow Some Use of the DSKY with a Failed Key. A program can be entered via the uplink that will allow a limited use of the DSKY with a failed key. This requires the use of the PRO key on the DSKY.

LEP 011 (EMP 110) Backup Event Timer. This program would allow the DSKY to be used as an event timer when the vehicle event timer is not usable.

LEP 014 (EMP 108) Inhibiting T4RUPT Coarse Alignment of the IMU. The T4RUPT coarse alignment of the IMU can be inhibited thereby allowing continuous gyro torquing of the platform and vehicle. Also will prevent a bad followup lag in gimbal lock recovery.

LEP 016 (EMP 104) P20 Operation with the IMU Off. Allows use of P20 for navigation without the requirement of having the IMU on.

LEP 018 (EMP 103) Performing Descent with Failed CDU’s. Allows some use of P63, P64, and P66 during descent without some combinations of CDU’s. Procedure varies with which CDU has been failed.

LEP 017 (EMP 107) P40 Operation with Failed CDU. Allows use of the major burn programs with some combinations of failed CDU’s. Procedure varies with which CDU is failed.

LEP 019 (EMP 106) P41, P42 with Failed CDU. Allows use of the major burn programs with some combinations of failed CDU’s. Procedure varies with which CDU is failed.

LEP 020 (EMP 107) Displaying Raw LR H and H DOT on the DSKY. Allows use of raw landing radar data to be used and checked on the DSKY.

LEP 023 (EMP 101) RR CDU Failure Workarounds.

LEP 031 (EMP 99) EMP for Guided RCS Translational Maneuvers (P99). See description in LM Software Section.

LEP 032 (EMP 103) EMP for P47 with DPS/GTS (Gimbal Trim System). Allows use of P47 with the DPS engine as the S/C propulsion source.
LGC Erasable Memory Procedures

LEP 004  State Vector Readout for Transfer to the CMC.  Flight Crew G&N dictionary page 1-75.
LEP 005  V36 Recovery.
LEP 113  Enable V40N20E (Coarse Alignment) in Apparent Gimbal Lock.
LEP 114  Onboard Computation of NBDX.