P00—CMC IDLING PROGRAM

Purpose:
1. To maintain the CMC 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. P00 integration will resume when P00 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 1520 will occur if a change is attempted when inhibited.

Sequence of Events:
V37E00E
V06N38E
Optional Display
V06N38 Time of State Vector Being Integrated 00XXX h 000XX min 0XX.XX s

P01—PRELAUNCH OR SERVICE—INITIALIZATION PROGRAM

Purpose:
1. To initialize the platform for the prelaunch programs.
2. To provide an initial stable member orientation for Gyrocompassing (P02).

Assumptions:
1. Erasable locations have been properly initialized. (Azimuth, +1; Latitude, +1; LAUNCHAZ, +1; IMU compensation parameters).

Sequence of Events:
V37E01E
No Att Light — ON, then OFF. Initiates the system and coarse aligns the platform to the desired orientation.
AGC advances to P02.

P02—PRELAUNCH OR SERVICE—GYROCOMPASSING PROGRAM

Purpose:
1. To provide the proper stable member orientation for launch.

Assumptions:
1. This program may be interrupted to perform the Prelaunch or Service—Optical Verification of Gyrocompassing program (P03).
2. V75 will be keyed in and displayed during this program to permit crew backup of the liftoff discrete.
3. The program is automatically selected by the Initialization program (P01).
4. This program has the capability (via V78E) to change the launch azimuth of the stable member while gyrocompassing.
P02—PRELAUNCH OR SERVICE—OPTICAL VERIFICATION OF GYROCOMPASSING

Purpose:
1. To provide an optical check for verification of alignment of the stable member during gyrocompassing prior to launch.
2. To check for proper damping of transients.
3. To check for proper alignment of the stable member.

Assumptions:
1. The astronaut has zeroed the optics just prior to program (P03) selection.
2. A minimum of 45 minutes between V78E and P03 (V65E) assures proper damping of transients.
3. The optics are in manual mode.
4. The CMC is in the power up condition.
5. The AGC is in the power up condition.

Sequence of Events:
Zero Optics for 15 seconds.
V65E
P03 displayed.
Flash XSM Target Azimuth
Target elevation
Target ID
XXX.XX deg
00001
Target 1 coordinates.
V24E. Change azimuth and elevation if desired.
PRO
Flash XSM Target Azimuth
Target elevation
Target ID
XXX.XX deg
00002
Target 2 coordinates.
V24E. Change azimuth and elevation if desired.
Optics Mode — CMC.
PRO
CMC drives optics LOS to Target 1.
Flash XSM
Optics to Manual — Mark on Target 1.
Flash XSM
Request terminate Mark sequence.

P03—CMC POWER DOWN PROGRAM

Purpose:
1. To transfer the CMC from the operate to the standby condition.

Assumptions:
1. If the computer power is switched off, the AGC Update program (P27) would have to be done to update the state vector and computer clock time.
2. The AGC is capable of maintaining an accurate value of ground elapsed time (GET) for only 23 hours when in the Standby mode. If the AGC is not brought out of the standby condition to the running condition at least once within 23 hours, the AGC value of GET must be updated.
3. Once the program has been selected, the AGC must be put in Standby. When P06 appears, the AGC will not honor a new program request (V37E), a terminate (V34E), or an ENTER in response to the request for standby.

Sequence of Events:
V37EO6E
Flash XSM Checklist Code
00002
Power down AGC.
If IMU power off desired — (CB). IMU Operate — open.
PRO
Until Standby light on.
TURN-ON
Standby light on.
PRO
Until Standby light off.
Flash XSM
00E Select P00
If IMU power up desired — (CB). IMU Operate — close.
No Att light on for 90 seconds.
P11—EARTH ORBIT INSERTION MONITOR PROGRAM

Purpose:
1. To indicate to the astronaut that the AGC has received the liftoff discrete.
2. To generate an attitude error indication on the FDI error needles, scaled for the 50/15 setting: from liftoff to the beginning of pitchover/rollout the attitude error is equal to the difference between the current vehicle attitude and the attitude stored at liftoff. During pitchover/rollout the attitude error is equal to the difference between the current vehicle attitude and the AGC nominal computation of vehicle attitude based on the stored polynomials in pitch and roll.
3. To display AGC computed trajectory parameters.
4. AGC takeover of Saturn during Boost
   a. Automatic Control—First Stage Only: should the Saturn platform fail the astronaut may set the LV Guidance Switch to the CMC position. This stores the current attitude errors as a bias. The Attitude Error routine for each cycle thereafter will compute the attitude error, subtract the bias, and transmit the difference information to the Saturn Instrumentation Unit (IU) for steering.
   b. Manual Control—The astronaut may select the Saturn stick function via V46E (DAP configuration = 3). This will terminate the Attitude Error routine.

Assumptions:
1. The program is normally automatically selected by the Gyrocompassing program (P02) when the AGC receives the liftoff discrete from the S1VB. In the backup case it would have been selected by keying in V75 ENTER.
2. The orbit parameter display routine is available by keying in V82E.

Sequence of Events:
V75 Enter is not keyed unless the liftoff discrete fails and P11 does not start automatically.
P11 displayed — Average G on.
V06N82 Inertial Velocity Magnitude XXXXX ft/s
V15N42 Altitude Rate XXXXX ft/s
V18N54 Altitude XXXXX nmi
Pitch/roll polynomial start at liftoff +10.97 seconds.
Terminate polynomial at liftoff +155.22 seconds.
V82E Orbital parameter display.
Flashing Apogee Altitude XXXXX nmi
Flashing Perigee Altitude XXXXX nmi
Flashing TFF
PRO
V37E00E
Average G off. P00 is selected.
V46E While in P11 will terminate polynomial computations and enable the RHC to steer the Saturn vehicle through the AGC interface.

P15—TLI INITIATE/CUTOFF

Purpose:
1. Provide backup for initiation of Saturn Time Base 6 (TB6), S-IVB, injection sequence start.
2. Provide TLI burn monitor capability during a Saturn IU controlled TLI maneuver (Saturn DAP in IU/Display Operational Mode).
3. Provide automatic TLI shutdown capability during a CMC controlled TLI maneuver (Saturn DAP in CMC/Steer Operational Mode).

Assumptions:
1. The TLI target parameters VI C/O (velocity magnitude at cutoff), TB6 (GET of TB6 initiation), and DTF (a bias to compensate for tailoff Delta V and actuator delays) are all available.

Sequence of Events:
V37E15E
Flashing V06N33 GET of TB6 Initiation 00XX h 00XX min 0XX XX s
V25E to Load desired TB6 time.
PRO
Flashing V06N14 Velocity Magnitude at S-IVB Cutoff XXXXX ft/s
V21E to Load desired velocity magnitude
PRO
V06N95
Flashing V06N95 Velocity Magnitude at S-IVB Cutoff XXXXX ft/s
V16N95 Time From TLI Ignition (TFI) XXbXX min/s
V15N44 Velocity to be Gained (Vg) XXXXX ft/s
V18N54 Velocity Magnitude (Vmag) XXXXX ft/s
UPLINK activity light and S-IVB injection sequence start discrete ON for 10 seconds at TB6 start time (TIG minus 9 minutes 38 seconds).
DSKY blanks for 5 seconds at TIG minus 105 seconds.
Average G on at TIG minus 100 seconds.
V06N95 returns.
At ignition plus 10 seconds, R1 equals time from cutoff (TFC).
Flashing V16N95 Same as N95 above but S-IVB cutoff discrete issued when VI C/O attained.
PRO
Flashing V37 Select New Program
P20 — UNIVERSAL TRACKING

Purpose:
1. Control CSM attitude/optics or attitude rates depending on which of the following five options is selected.

   Option 0 — Point a specified S/C vector along the LOS to the LM without constraining rotation about the vector (VECPOINT). This option is used to acquire the LM in the SXT field of view and to point the CSM transponder at the LM.

   Option 1 — Point a specified S/C vector at a specified celestial body without constraining rotation about the vector (VECPOINT).

   Option 2 — Perform rotation about a specified S/C vector at a specified rate and beginning at a specified time. This option is normally used to effect PTC or initiate pitchover for landmark tracking.

   Option 4 — Point a specified S/C vector along the LOS to the LM while constraining rotation about the vector (three-axis). This option is used to acquire the LM in the SXT field of view and to point the CSM transponder at the LM.

   Option 5 — Point a specified S/C vector at a specified celestial body while constraining rotation about the vector (three-axis).

2. Update the LM or CSM State vector on the basis of optical tracking data and/or VHF range data (Options 0 and 4 only).

Assumptions:
1. The GNCS is normally in control of the vehicle in the Auto mode. If the astronaut assumes control of the vehicle with the RHC, the CSM will remain at the attitude it is driven to. Regardless of mode selection the CMC will calculate the desired tracking attitude.

2. The LM is maintaining a preferred tracking attitude to correctly orient the optical beacon (Options 0 or 4).

3. During rendezvous, W-matrix initialization is enabled by keying V93E, a fresh start (V36E), uplinked state vector update, automatically during MINKEY, and upon entering P22, P23, or P24.

4. The optics and VHF ranging mark counters are used to count the number of marks, by source, which are used to update either state vector. The counters are zeroed by W-matrix initialization, completion of P37, and by a fresh start.

5. This program may be selected manually or internally by the MINKEY controller.

Sequence of Events:
Option 4 may be initiated automatically by the MINKEY controller. The sequence will start at MANEUVER below if automatic initiation.

V36E (continued)

PRO

Flashing = GAMMA XXX.XX deg
VO8N72 = RHO XXX.XX deg
OMICRON XXX.XX deg
V26E to Load the desired coordinates.

GAMMA, RHO are rotational coordinates of the desired pointing axis or axis of rotation. The coordinates represent Euler rotations of the S/C +X axis about the +Z axis and then about the new +Y axis.

OMICRON is an attitude constraint about the pointing vector for three-axis options. It is ignored in VECPOINT options.

0° = Heatshield forward/heads up
180° = Apex forward/heads down

V24E to Load desired rate and deadband.

PRO to appropriate option

CELESTIAL BODY TRACK

Flashing = Desired Rate (Option 2 only)
VO8N79 = Desired Deadband
XXX.XX deg/s
XXX.XX deg
V21E to load desired Star Code.

PRO if Star Code ≠ 00, GO to MANEUVER

Flashing = Unit position vector
VO8N88 = of desired planet
XXX.XX
YYY.XX
ZXX.XX
V25E to load position vector.

PRO to MANEUVER
NOTATION

Flashing V06N34
GET at which rotation maneuver is to start 60 XX.XX h
60 XX.XX min 6XX.XX s

V25E to load desired GET (all 0's specify present time)

PRO to TERMINATE (rotation will commence at specified GET)

RENDZEVOUS

MANEUVER

Note: P20 (R61) will maintain tracking attitude computations. If the attitude error becomes greater than 10 degrees, the astronaut will be alerted by:

UPLINK ACTY light on

If the tracking attitude error is less than 10 degrees, proceed to the appropriate marking sequence.

The attitude error is defined as:

P20 Options 0 & 1 - Angular error between the vehicle pointing axis and the LOS to the target with no angular constraint about the pointing vector.

P20 Options 4 & 5 - Angular errors between the actual and desired gimbal angles required to align the vehicle pointing axis along the LOS to the target and constrain the rotation about the pointing vector.

V68E Request autonomous maneuver execution.

Flashing Desired FDAO angles for OGE (R) XXX.XX deg
V68N18 autonomous
LG (R) XXX.XX deg
MG (R) XXX.XX deg

PRO V68N18 Maneuver in progress
Flashing Maneuver Complete V68N18
ENTER Terminates autonomous maneuver routine, if random option go to appropriate marking sequence, otherwise go to TERMINATE.

OPTICS MARKING

The rendezvous sighting mark routine is called automatically. Proceed with optics marking.

VHF RANGE MARKING

If MINKEY controller active, VHF marking is initiated automatically when the range is within 027.XX nmi.

V87E Sets VHF Range Flag manually.

Enables ranging marks for use by R22 at 1 minute intervals.

V88E Restarts VHF Range Flag manually.

Disables ranging marks. Use V87E to reenable.

BACKUP CGAS MARKING

V54E Calls the backup sighting mark routine.

Flashing Optics angle coordinates V06N34 for alternate LOS (CGAS) SHAFT XXX.XX deg

V34E to load coordinates.

CGAS LOS coordinates can be determined by sighting on a horizon star and using VS52 to compute the desired optics angles to acquire the star in the SXT field.

PRO Flashing MARK Counter (VHF - Optics) V05N45 XX.XX

TFI of Next Burn XXX.XX msec

MGA at TIG XXX.XX deg

TFI and MGA are computed by targeting program, if running.

ENTER Used for marking with CGAS. V88E is used to reject a backup mark.

Note: V76 may be modified to specify +X axis pointing for CGAS marking at any time. The program will calculate a maneuver to +X axis tracking attitude.

UPDATE DISPLAY

If any mark produces a state vector position or velocity magnitude change greater than a preloaded value, the astronaut receives a display of the data for approval/disapproval.

Flashing V06N40 Delta R XXX.XX nmi
Delta V XXX.XX ft/s
Source Code 1 - OPT, 2 - VHF

PRO Used data and updates the state vector.

V32E Rejects mark data and state vector update not done.

TERMINATE

V56E Flashing V37 Select New Program

P21-GROUND TRACK DETERMINATION PROGRAM

Purpose:
1. Provide astronaut with details of his ground track.

Assumptions:
1. Can be used while CSM is in either earth or lunar orbit to determine ground track of either LM or CSM.
2. Vehicle whose ground track parameters are calculated to remain in the present until T Lat Long.

Sequence of Events:

V37E21E Flashing V04N06 Option Code (specify vehicle) XXXX:0002
Vehicle Code (1 - CSM, 2 - LM)

CSM is assumed: If LM is desired, V22E2E

PRO Flashing V06N34 Time Lat/Long
V06N34 00000.XX:00000.XX

V25E. Key in time at which vehicle position is desired. Time = 0 specifies present time.

PRO Flashing V06N43 Latitude of Vehicle
V06N43 XXX.XX deg (+ north)
Longitude of Vehicle XXX.XX deg (+ east)
Altitude Above Launch Pad/Landing Site
V06N43 XXX.XX nmi

V32E Recycles to Flashing V06N34 for new display.

V06N73E Optional Display

Flashing V06N73 Attitude
V06N73 XXX.XX nmi
Velocity XXX.XX ft/s
Flight Path Angle
V06N43 XXX.XX deg

KEY REL

Flashing V06N43 Same as N43 above.

PRO Flashing V37 Select New Program.
P22—ORBITAL NAVIGATION PROGRAM

Purpose:
1. Locate and track landmark suitable for navigation purposes.
2. Obtain sighting marks on chosen landmark.
3. Compute the orbital parameter changes generated by landmark sightings.
4. Update state vector as result of sightings (if sightings ok).
5. Update coordinates of known landmarks.
6. Provide coordinates of unknown landmarks.
7. Track preloaded landing site.
8. Provide coordinates of new landing site.
9. Provide coordinates of an offset landing site.
10. Align optics along an advanced orbit ground track for purpose of tracking and mapping a new landing site.

Assumptions:
1. There are two types of landmark tracking methods:
   a. "Known" Landmark Tracking—The tracking of an earth landmark made known to the AGC by latitude, longitude/2, and altitude, and the tracking of a lunar landmark made known to the AGC by latitude, longitude/2, and altitude.
   b. "Unknown" Landmark Tracking—The tracking of a landmark or surface feature identified to the AGC as an unknown landmark, one whose coordinates are not known.
2. There are two types of landing site mapping methods:
   a. Landing Site Designation—Track and mark on an unknown landmark. The resulting coordinates in Landmark Code 01. If mapping only is desired (that is, no state vector calculation or corrections), the astronaut need take only one mark.
   b. Landing Site Offset—While tracking and marking on a primary landmark (known or unknown), point the optical SLOS at the chosen landing site and mark it once, at least one mark on the primary landmark must be made prior to this; then continue marking on the primary landmark. Store the resulting coordinates of the offset landing site in Landmark Code 01.
3. Acquisition of a landmark may be aided by the AGC by use of the Automatic Optics Positioning routine (R52).
4. Acquisition of a preloaded landing site may be aided by keying Landmark Code 01 into the V05 N70 display for use by the Automatic Optics Positioning routine (R52).
5. The Ground Track Determination program (P21) is available to aid the crew in choosing appropriate landmarks prior to selection of this program.
6. The Ground Track Determination program (P21) is available to the crew following this program to provide updated ground track information.
7. Possible attitude control methods might be as follows (in all cases care must be taken to monitor possible impending IMU gimbal lock):
   a. Manual control by the pilot or navigator with the rotational hand controller.
   b. Manual rate control by the navigator with the minimum impulse control in the GN C/TC mode.
   c. Automatic pitchover maneuver via V20, Option 2.
8. Selection of this program will terminate Options 0 and 4 of P20.

Sequence of Events:
V37E22E
Flashing V05N45
Maximum MGA with Spacecraft X Axis
V05N69
In Orbital Plane
Flashing V05N70
If expected MGA is greater than 60 degrees, exit P22 and realign IMU (P52).

P22 (continued)

ZERO Optics for 12 seconds.

OPTICS Mode—CMC

PRO: If in earth orbit go to Flashing V05N69 below.
Flashing V05N70
Landmark Code (R2)
A = (known landmark), 2 (unknown landmark)
B = index of offset indicator
C = not used
DE = Landmark ID (00, 01, or 0X)

V22E to Load LMK Code
PRO: If A = 2; Optics meds to manual and to go Flashing V51; if A = 1 and DE = 00, go to Flashing V05N69.
Flashing V05N69
Landmark Latitude
Longitude/2
Altitude of LMK

V25E: Load landmark coordinates.
PRO: V05N62
Auto position optics to landmark or, if DE = SX, to 60 degrees ahead of vehicle location on ground track.

OPTICS Mode—Manual

V51
Request marks.

MARK
Offset landing site mark followed by V52E.
Flashing V05N25
Checklist Code
00016 (after five marks taken)

PRO: Terminate mark sequence.
Flashing V05N71
Same as N70 above.

V22E to correct data.

V25E: Insure B corresponds to the mark on offset landing site or is set to zero.

PRO: V05N69
Flashing V05N69
Same as N70 above.

V25E to correct data.

V32E to reject data and recycle to Flashing V05N70.
Flashing V06N69
Same as N70 above except an update of landmark coordinates or map of offset landing site coordinates or map of unknown landmark. If this landmark or offset landing site is desired as the new landing site, key V32E to update landing site coordinates and recycle to Flashing V05N70 display. To retain landing site but edit the tracking, key PRO and recycle to Flashing V05N70 display.

V34E
Flashing V37
Select New Program.
P23—CISLUNAR MIDCOURSE NAVIGATION PROGRAM

Purpose:
1. To do midcourse navigation by incorporation of star/earth and star/moon optical measurements.

Assumptions:
1. Prior to each mark, the program will call for an optics calibration which may be done or bypassed dependent upon the stability history of the calibration.
2. To perform the mark, the astronaut should finally select minimum impulse control (either GNCS or SCS) and the optics should be in manual in order to maintain the fix.
3. The optics should be on for 15 minutes prior to marking.
4. The AGC does not check for moon/earth occultation or sun brightness in this program.
5. Nouns 70 and 71 are checked to assure that the codes fall within certain permissible limits. Check to assure that R2 and R3 do not both equal zero or do not both not equal zero. If R1 = 0, R2 = 0, and R3 = 0, Nouns 70 and 71 are checked to assure that the values for R1 and R2 fall within certain defined limits (90 degrees to +90 degrees).
6. Noun 88 allows that any proportional set of components may be loaded for planet direction. However, a unit vector is recommended.
7. Selection of this program will terminate Options 0 and 4 of P20.

Sequence of Events:
V37E23E
Flashing Checklist Code 00015
V50N25
Perform celestial body acquisition.

PRO
If manual acquisition desired, key ENTER and go to Flashing V58.
Flashing Star ID Code
V04N70
V21E to load star ID code XX.

PRO
If star ID = 00, go to Flashing V50N18.
Flashing Unit Position
V06N38
Vector of Planet
Z XXXXX
V25E to load planet vector.

PRO
Flashing Desired FDDA Angles for
V50N18
Automanuever
OG(n1) XXXXX deg
IG(p1) XXXXX deg
MG(v1) XXXXX deg

OPTICS ZERO for 16 seconds
OPTICS Mode — Manual
PRO
Automanuever LLOS to selected star.
V06N18
Maneuver in process.
Flashing Maneuver complete.

ENTER
Terminate maneuver routine.
Flashing Request optics calibration mark.
V58
To bypass optics calibration, key ENTER and go to Flashing V05N70.
P23 (continued)

PRO Terminate mark sequence.
    Flashing Same as N70 above.
    V06N71
    V25E to correct data.

PRO If PLANET/HOR sighting, go to Flashing V06N88.
    If STAR/HOR sighting, go to Flashing V06N49.
    Flashing V06N89 Same as N89 above
    V25E to correct landmark coordinates

PRO If Star/LMK sighting, go to Flashing V06N49
    Flashing V06N88
    V25E to correct planet vector.

PRO State vector update computed.
    Flashing Delta R XXX.XX nmi
    V06N49 Delta V XXX.XX ft/s
    V25E to load approximate landmark coordinates.

Accept data. V32E reject data, go to Flashing V37.
    Flashing Select New Program.

P24—RATE AIDED OPTICS TRACKING PROGRAM

Purpose:
1. To locate and acquire a given landmark via the automatic optics positioning routine
   (R52) with the Optics Mode switch in the CMC position.
2. When acquired, to track the given landmark via the rate-aided optics feature of the
   automatic optics positioning routine with the optics in the Manual position.
3. To obtain and downlink to the ground an unlimited number of sighting marks on the
   chosen landmark and to update the landmark coordinates.

Assumptions:
1. The coordinates of the landmark are known approximately.
2. At low altitudes, tracking may be facilitated by manually initiating a pitch-over
   maneuver via P20, Option 2.
3. The astronaut will assist in the tracking of the chosen landmark when in the
   rate-aided mode (Optics switch in Manual) by supplying inputs via the optics hand
   controller.
4. Selection of this program will terminate Options 0 and 4 of P20.

P24 (continued)

Sequence of Events:
V37E24E
    Flashing Landmark Latitude XX.XXX deg
    V06N89 Longitude/2 XX.XXX deg
    Altitude XXX.XX nmi
    V25E to load approximate landmark coordinates.

ZERO OPTICS for 15 seconds.

OPTICS Mode — CMC
    PRO
    V06N92 Desired Optics Angles
    Shaft XXX.XX deg
    Trunnion XXX.XX deg

AGC will auto-position the optics LOS to the landmark. The AGC will update the
desired optics angles each 0.05 second plus integration time.

OPTICS Mode — Manual
    Flashing AGC will now compute optics drive rates to maintain
    V61 the landmark track by back differencing the desired optics
    angles and compensating for computational and system delays.
    Desired optics angles are updated with state vector and landmark
    updates.

Adjust tracking rate with optics hand controller
    Provide a manual optics drive assist to trim the AGC commanded drive rate for
    aligning the target and reticle. AGC commanded rates are updated through subsequent
    marking and landmark updates.

MARK
    Unlimited marking is accepted. Marks are transmitted downlink and are used to update
    the landmark coordinates when the number of R52 cycles since the last landmark update
    reaches a prelaunch erasable value. The landmark update is subsequently used to
    update the desired optics drive rate and maintain the landmark track.

PRO Terminates Program.
    Flashing Select New Program
    V37
P27—AGC UPDATE PROGRAM

Purpose:
1. To insert information into the AGC via the digital uplink by transmission from the ground or via the DSKY keyboard by crew manual input.

Assumptions:
1. AGC updates are of four categories:
   a. Provide an update for AGC liftoff time (V70).
   b. Provide an octal increment for the AGC clock only (V73).
   c. Provide load capability for a block of sequential erasable locations (1-18 inclusive locations whose address is specified) (V71).
   d. Provide load capability for 1-9 inclusive individually specified erasable locations (V72).
2. Update is allowed in the CSM when the AGC is in P00, P02 or P20 (Options 1, 2 or 5), and if the DSKY is available.
3. The UPTEL Accept/Block switch must be in Accept for telemetry update.
4. The automatic mode of update is program selection and update via the ground by uplink transmission. The only difference between this and manual selection by the astronaut is that the DSKY responses are keyed in by the astronaut rather than transmitted.

Sequence of Events:
- Select P00 if P00, P02, P20 (Options 1, 2, or 5) not selected.
- Up Telemetry switch — Accept Enable Uplink.
- Uplink Acty light — On Program selected via Uplink. Mode window displays 27.
- Returns to program selected prior to P27 update
-Up Telemetry switch — Block Disable uplink.

P29—TIME OF LONGITUDE

Purpose:
1. To provide the astronaut with an estimated time of passage over a selected longitude.

Assumptions:
1. This program may be selected while the CSM is in either earth or lunar orbit to find the time of longitude of either the CSM or LM.
2. This program assumes the vehicle whose ground track parameters are calculated remains in freefall from the selected start time until the time of longitude crossing.

Sequence of Events:
- V37E29E
  - Flashing Option ID Code 00002
  - V04N06 Vehicle Option (1—CSM, 2—LM) 0000x
  - V22E to load desired vehicle code.

PRO
- Flashing V06N34 GET at which CMC begins search (all 0's for present time) 0000X h 00XX.XX min 0XX.XX s
- V25E to load desired time.

PRO
- Flashing V06N43 Desired Longitude (R2) XXX.XX deg
- V22E to load desired longitude.

PRO
- Flashing V06N34 Time of longitude crossing 00XXX h 00XX.XX min 0XX.XX s
- PRO V32E to previous flashing V06N43 to change longitude.

PRO
- Flashing V06N43 Latitude at Longitude Crossing XXX.XX deg
- Flashing V06N43 Longitude Specified XXX.XX deg
- Flashing V06N43 Altitude of Vehicle at Longitude Crossing XXXX.XX nmi

PRO
- V32E to Flashing V04N06 to recycle.
- Flashing V37 Select New Program
P30—EXTERNAL DELTA V PROGRAM

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

Assumptions:
1. Target parameters (TIG and ΔV(LV)) may have been loaded from the ground during a prior execution of P27.
2. External Delta V flag is set during the program to designate to the thrusting program that external Delta V steering is to be used.

Sequence of Events:
V37E30E
Flashing Ground Elapsed Time of Ignition (TIG) 00XXX. h
V06N33 00XX. min
V03N31 0XX.XX s
V25E to load desired TIG.

PRO
Flashing Impulsive ΔV at TIG X XXX.X ft/s
V06N91 Y XXX.X ft/s
V03N92 Z XXX.X ft/s
V25E to load desired ΔV.

PRO
Flashing Apogee/Apolune Altitude XXXX.X nmi
V06N42 Perigee/Perilune Altitude XXXX.X nmi
V03N41
Flashing Magnitude of ΔV at TIG XXXX.X ft/s
V03N41
Flashing Mark Counter (VHF—Optics) XXbXX marks
V16N45 Time from Ignition (TFI) XXbXX min/s
V03N41
Middle Gimbal Angle at TIG with Vehicle +X Axis in Direction of Thrust XXX.XX deg
V03N41
If the REFSMMAT flag is reset (that is, the IMU is not aligned) MGA will equal -00002.

PRO
Flashing V37 Select New Program.

P31—HEIGHT ADJUSTMENT MANEUVER (HAM) PROGRAM

Purpose:
1. To calculate the parameters associated with the Height Adjust Maneuver (HAM) for ΔV burns.
2. To store the HAM target parameters for use by the desired thrusting program.

Assumptions:
1. At a selected TPI time the line of sight between the CSM and the LM is selected to be prescribed angle (E) from the horizontal plane defined at the active position.
2. CDH ΔV is selected to minimize the variation of the altitude difference between the orbits.
3. HAM burn is defined such that the impulsive ΔV is in the horizontal plane defined by the active vehicle position at HAM Ignition.
4. 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 the program.
5. The CSI and CDH maneuvers are originally assumed to be parallel to the plane of the LM orbit. Out-of-plane parameters are computed for TIG (HAM) and displayed. In addition, the N81 display is modified to establish an antinode at HAM.
6. If P20 is in operation while the program is operating, the astronaut may hold at any flashing display and turn on the rendezvous sighting mark routine, take optics marks and/or allow VHF ranging marks to accumulate.
7. TIG (HAM) is computed to be 180 degrees central angle before TIG (CSI).
8. The ISS need not be on to complete this program unless automatic state vector updating is desired by the Universal Tracking program (P20).
9. The external ΔV flag is set during this program to designate to the thrusting program that external ΔV steering is to be used.
10. This program may be selected manually or internally by the MINKEY controller.
Sequence of Events:

If entered automatically by MINKEY controller, go to MANEUVER.

V37E31E

Note: If P20 rendezvous option is not running, P20 Option 4 is activated now.

Flashing MINKEY Rendezvous Option
V50N25 Checklist Code 00017

PRO Enters MINKEY automatic rendezvous sequencing.
ENTER Enters manual sequencing.

MANEUVER

Note: P20 (R61) will maintain tracking attitude computations. If the attitude error becomes greater than 10 degrees, the astronaut will be alerted by:

- UPLINK ACTY light on
- If the tracking attitude error is less than 10 degrees, proceed to TARGETING.

The attitude error is defined as:

- P20 Options 0 & 1 — Angular error between the vehicle pointing axis and the LOS to the target with no angular constraint about the pointing vector.
- P20 Options 4 & 5 — Angular errors between the actual and desired gimbal angles required to align the vehicle pointing axis along the LOS to the target and constrain the rotation about the pointing vector.

V58E

Request automatic maneuver execution.

Flashing Desired DDAI angles for
V50N18 maneuver

PRO

V06N18 Maneuver in progress

If MINKEY sequence, go to TARGETING when maneuver is completed.

Flashing Maneuve Complete (manual sequence)
V50N18

ENTER Terminates autonomous maneuver routine, go to TARGETING

TARGETING

Flashing GET of CSI Ignition TIG (CSI)
V06N11

V25E to load desired TIG.

PRO

Flashing Apсидal Crossing
V06N55 Elevation Angle
CENTANG

V25E to load desired data.

Apсидal crossing is the future line of apsis crossing where TIG (CDH) is to occur. Elevation angle is the angle between the CSM/LM LOS and the CSM local horizontal plane at TIG (TPI).

CENTANG is an option code where R3 f 0 specifies TIG (CDH) to occur at N (180) degrees from CSI maneuver and N = number entered in R1.

V25E to modify TIG.

PRO

Flashing Mark Counter (VHF-Optics)
V16N45 Time from Ignition TIG (HAN)

V25E to modify TIG.

PRO

Flashing Mark Counter (VHF-Optics)
V16N45 Time from Ignition TIG (HAN)

MARKER is displayed on the final pass through the program.

PRO Sets Final flag to execute final pass through program.

V32E Continues but Final flag not set.

Alarm Codes 00060 through 00606 may occur. If an alarm occurs, V32E recycles to V06N11 where the INPUT parameters may be adjusted for a new solution.

Flashing Out-of-Plane Position (Y), Active Vehicle
V06N90 Out-of-Plane Velocity (YDOT), Active Vehicle
Out-of-Plane Velocity (YDOT), Passive Vehicle

PRO

Flashing Delta V at TIG (HAN)
V06N81 in Local Vertical Coordinates

V25E to modify Delta V.

PRO

If Final flag not set go to previous flashing V16N45

Flashing Mark Counter (VHF-Optics)
V16N45 TFI (HAN)

MGA will be the MGA at TIG (HAN). If the IMU is not aligned, MGA will be 00002.

PRO

If MINKEY controller is active, W matrix reinitialization is performed and the appropriate burn program is initiated.

If Delta V solution < 7 ft/s, P41 is initiated.
If Delta V solution > 7 ft/s, P40 is initiated.

Flashing V37 Select New Program (manual sequence)
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 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 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 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 horizontal plane defined by the active vehicle position at CSI ignition.
6. The pericenter altitude of the orbit following CSI and CDH must be greater than 35,000 feet (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 LM orbit. However, out-of-plane parameters are computed for TIG (CSI) and displayed. In addition, the NS1 display is modified to establish an antinode at CSI.
8. If P20 is in operation while the program is operating, the astronaut may hold at any flashing display and take optics marks and/or allow VHF ranging marks to accumulate.
9. The ISS need not be on to complete this program unless automatic state vector updating is desired by the Universal Tracking program (P20).
10. The external Delta V flag is set during this program to des the program that external Delta V steering is to be used.
11. This program may be selected manually or internally by the MINKEY controller.

Sequence of Events:
If entered automatically by MINKEY controller, go to MANEUVER.

V37E32E
Note: If P20 rendezvous option is not running, P20 Option 4 is activated now.
Flash MINKEY Rendezvous Option V50N25 Checklist Code PRO Elects MINKEY automatic rendezvous sequencing.
Enter MARKS TO MARK MINKEY automatic rendezvous sequencing.

Note: P20 (R61) will maintain tracking attitude computations. If the attitude error becomes greater than 10 degrees, the astronaut will be alerted by:
ULD1 ACTIV light on.
If the tracking attitude error is less than 10 degrees, proceed to TARGETING.
The attitude error is defined as:

P20 Options 0 & 1 - Angular error between the vehicle pointing axis and the LOS to the target with no angular constraint about the pointing vector.

P20 Options 4 & 5 - Angular errors between the actual and desired gimbal angles required to align the vehicle pointing axis along the LOS to the target and constrain the rotation about the pointing vector.

V58E
Request automatic execution.
Flash Desired FDAI angles for automaneuver V50N18
PRO
V50N18 Maneuver in progress
IF MINKEY sequence, go to TARGETING when maneuver is completed.

V50N18 Maneuver Complete (manual sequence)

ENTER Terminates automaneuver routine, go to TARGETING

TARGETING

Flash GET of CSI Ignition TIG (CSI) V50N11

Flashing Apsidal Crossing V60N55 Elevation Angle CENTANG

Flashing GET of TPI Ignition TIG (TPI) V50N37

Mark Counter (VHF—Optics) V16N45

Mark Counter updated by P20 which may be running in the background.
MGA is only displayed on the final pass through the program.
P32 (continued)

Set Final flag.

V32 continues in program but Final flag is not set. Used when another pass is desired.

Alarm Codes 00600 through 00606 may occur. If an alarm occurs, V32E recycles to VO6N11 where the input parameters may be adjusted for a new solution.

If automatic MINKEY sequence, go to flashing VO6N90.

Flashing Delta Time of TIG (CDH) ______ min/s

TIG (CDH) is available by keying VO6N13E.

Flashing Out-of-Plane Position (Y) Active Vehicle XXX.XX nmi

VO6N9E Out-of-Plane Velocity (YD0T) Active Vehicle XXX.XX ft/s

Out-of-Plane Velocity (YD0T) Passive Vehicle XXX.XX ft/s

If automatic MINKEY sequence, go to Flashing V16N45.

Flashing Delta V at TIG (CSI) XXX.XX ft/s

VO6N81 In Local Vertical Coordinates Y XXX.XX ft/s

Z XXX.XX ft/s

If Final flag is reset, go to previous Flashing V16N45.

Flashing Mark Counter (VHF—Optics) XXX.XX deg

V16N45 MGA

MGA will be the MGA at TIG (CSI). If the IMU is not aligned, MGA will be -00002. (For LM solution (P72) MGA is always -00002 on the final pass.)

If MINKEY controller is active, W-matrix reinitialization is performed and the appropriate burn program is initiated.

If Delta V solution < 7 ft/s, P41 is initiated.

If Delta V solution ≥ 7 ft/s, P40 is initiated.

Flashing V37 Select New Program (manual sequence)

P33—CM3 CONSTANT DELTA ALTITUDE (CDH) PROGRAM

Purpose:
1. To calculate parameters associated with the Constant Delta Altitude maneuver (CDH), for Delta V burns.
2. To store the CDH target parameters for use by the desired thrusting program.

Assumptions:
1. This program is based upon previous completion of the Coelliptic Sequence Initiation (CSI) program (P32). Therefore:
   a. At a selected TPI 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 active vehicle 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 TPI ignition was computed to be greater than 10 minutes.
   d. The variation of the altitude difference between the orbits was minimized.
   e. CSI burn is defined such that the impulsive Delta V is in the horizontal plane defined by the active vehicle position 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, out-of-plane parameters are computed for TIG (CDH) and displayed. In addition, the N31 display is modified to establish an antinode at CDH.
2. If P20 is in operation while this program is operating, the astronaut may hold at any flashing display and take optics marks, and/or he may allow VHF ranging marks to accumulate.
3. The ISS need not be on to complete this program unless automatic state vector updating is desired by the Universal Tracking program (P20)
4. 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.
5. The ISS program may be selected manually or internally by the MINKEY controller.

Sequence of Events:

If entered automatically by MINKEY controller, go to MANEUVER.

V37E33E

Note: If P20 rendezvous option is not running, P20 Option 4 is activated now.

Flashing MINKEY Rendezvous Option V5ON25 Checklist Code 00017

PRO Elects MINKEY automatic rendezvous sequencing.

ENTER Elects manual sequencing.

MANEUVER

Note: P20 (R61) will maintain tracking attitude computations. If the attitude error becomes greater than 10 degrees, the astronaut will be alerted by:

UPLINK ACTY light on

If tracking attitude error is less than 10 degrees, proceed to TARGETING.

The attitude error is defined as:

P20 Options 0 & 1 — Angular error between the vehicle pointing axis and the LOS to the target with no angular constraint about the pointing vector.

P20 Options 4 & 5 — Angular errors between the actual and desired gimbal angles required to align the vehicle pointing axis along the LOS to the target and constrain the rotation about the pointing vector.
V58E

Request automaneuver execution.
- Flashing V50N18 Desired FDI angles for automaneuver
- O(R) XXX.XX deg
- I(G) XXX.XX deg
- M(C) XXX.XX deg

PRO
- V08N18 Maneuver in progress
- If MINKEY sequence, go to TARGETING when maneuver is completed.
- Flashing V50N18 Maneuver Complete (manual sequence)

ENTER Terminates automaneuver routine, go to TARGETING

TARGETING
- Flashing V06N13 GET of CDH Ignition TIG (CHD) 00XXX h 00XX min 0XX.XX s
- V25E to correct desired TIG.

PRO
- Flashing V16N45 Mark Counter (VHF—Optics) XbXX
- Time from Ignition TFG (CDH) XbXX min/s
- MGA Mark counter is updated by P20 which may be running in the background. MGA is only displayed on the final pass.

PRO Set Final flag. V32E continues in program but Final flag is not set. Used when another pass is desired.
- V22E may be used to recycle to V06N13 and readjust TIG.
- If automatic MINKEY sequence, go to Flashing V06N90.
- Flashing V06N75 Delta Time of TIG (CDH/TPI) XbXX min/s
- Delta Time of TIG (TPI/TP1) XbXX min/s
- TIG (TP1) is available by keying V06N37E.

PRO
- Flashing V06N90 Out-of-Plane Position (Y) Active Vehicle XXX.XX nm
- Out-of-Plane Velocity (YDOT) Active Vehicle XXX.XX ft/s

PRO
- Flashing V06N91 In Local Vertical Coordinates X XXX.XX ft/s
- Y XXX.XX ft/s
- Z XXX.XX ft/s

PRO If Final flag is reset go to previous Flashing V16N45.
- Flashing V16N45 Mark Counter (VHF—Optics) XbXX
- TFG (CDH) XbXX min/s
- MGA Mark Counter (VHF—Optics) XXX.XX deg
- MGA will be the MGA at TIG (CDH). If the IMU is not aligned, MGA will be -00002. (For LM solution P73) MGA is always -00002 on the final pass.

PRO If MINKEY controller is active, W-matrix reinitialization is performed and the appropriate burn program is initiated.
- If Delta V solution < 7 ft/s, P41 is initiated.
- If Delta V solution >7 ft/s, P40 is initiated.
- Flashing V37 Select New Program (manual sequence)
Sequence of Events:

- If entered automatically by MINKEY controller, go to MANEUVER.
- Note: If P20 rendezvous option is not running, P20 Option 4 is activated now.

**V37E3E**

- Flashing: MINKEY Rendezvous Option
- V6NB5: Checklist Code 00017

- **PRO** Selects MINKEY automatic rendezvous sequencing.
- **ENTER** Selects manual sequencing.

**MANEUVER**

- Note: P20 (R61) will maintain tracking attitude computations. If the attitude error becomes greater than 10 degrees, the astronaut will be alerted by: UPLINK ACTY light on.
- If tracking attitude error is less than 10 degrees, proceed to TARGETING.

- The attitude error is defined as:
  - P20 Options 0 & 1: Angular error between the vehicle pointing axis and the LOS to the target with no angular constraint about the pointing vector.
  - P20 Options 4 & 5: Angular errors between the actual and desired gimbal angles required to align the vehicle pointing axis along the LOS to the target and constrain the rotation about the pointing vector.

**V5BE**

- Request autonomous execution.
- Flashing: Desired FDAI angles for automaneuver
- V6NB18: Maneuver in progress
- If MINKEY sequence, go to TARGETING when maneuver is completed.
- Flashing: Maneuver Complete (manual sequence)
- **ENTER** Terminate autonomous maneuver routine, go to TARGETING.

**TARGETING**

- Flashing: GET of TPI Ignition TIG (TPI) 00XXX h 00XXX min 00XXX s
- V25E to correct desired TIG.

- **PRO**
  - Flashing: Number of Precision Offsets CENTANG XXXXX deg
  - V6NB5 to load desired data.
  - Number of precision offsets is an integration code where X = 0 specifies integration of a conic trajectory to generate the target vector and X ≠ 0 specifies precision integration to generate the target vector. If precision integration is desired, X should equal 2.
  - Elevation angle is the angle between the CSM/IM LOS and the CSM local horizontal at TIG (TPI). E should = +000000 if E is to be computed at TIG specifies.
  - (For LM solution (P74), MGA is always -00002 on the final pass.)
  - CENTANG is the orbital angle traversed by the passive vehicle from TIG (TPI) to time of intercept.

- **PRO**
  - Flashing: Mark Counter (VHF—Optics) XXbXX
  - V6NB45: MGA at TIG (TPI) 00001
  - Mark counter is updated by P20 which may be running in the background.
  - MGA is -1 until the final pass of the program.

- **PRO**
  - Flashing: Select New Program (manual sequence)

**COMPUTE ELEVATION ANGLE FOR GIVEN TIG**

- If elevation angle above was = 0,
  - Flashing: Same as N55 above, except elevation angle has been computed.

**COMPUTE TIG FOR GIVEN ELEVATION ANGLE**

- If elevation angle above was ≠ 0,
  - Flashing: Time of Ignition for Specified Elevation Angle TIG (TPI) 00XXX h 00XXX min 00XXX s
  - If MINKEY FINAL PASS, set E = 0 and go to COMPUTE ELEVATION ANGLE FOR GIVEN TIG above.

- Note: If alarm 00611 occurs, PRO to TARGETING at start of program.

- **PRO**
  - Flashing: Longitude Altitude (Post-TPI) XXXXX X nmi
  - V6NB56: Delta V Required for TPI XXXXX ft/s
  - Delta V Required for TPF XXXXX ft/s

- **PRO**
  - Flashing: Delta V at TIG (TPI) in Local Vertical Coordinates X XXXXX ft/s Y XXXXX ft/s Z XXXXX ft/s

- **PRO**
  - If final flag is reset, go to previous flashing V16N45.
  - Flashing: Mark Counter (VHF—Optics) XXbXX
  - V6NB45: MGA at TIG (TPI) XXbXX min/s
  - Delta V at TIG (TPI) in Local Vertical Coordinates X XXXXX ft/s Y XXXXX ft/s Z XXXXX ft/s

- **PRO**
  - If MINKEY controller is active, W-matrix reinitialization is performed and the appropriate burn program is initiated.
  - If Delta V solution <7 ft/s, P41 is initiated.
  - If Delta V solution ≥7 ft/s, P40 is initiated.
  - Flashing: V37 Select New Program (manual sequence)
P35—CSM TRANSFER PHASE MIDCOURSE (TPM) TARGETING PROGRAM

Purpose:

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

Assumptions:

1. If P20 is in operation while this program is operating, the astronaut may hold at any flashing display and take optics marks, and/or he may allow VHF ranging marks to accumulate.

2. 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 the expected maneuver time.

3. The time of intercept (TINT) was defined by previous completion of the Transfer Phase Initiation (TP1) program IP-341 and is presently available in AGC storage.

4. ISS need not be on to complete this program unless automatic state vector updating is desired by the Universal Tracking program.

5. The external Delta V flag is reset during this program to designate to the thrusting program that Lambert steering is to be used.

6. The Delta V in LOS coordinates is available in N59.

7. The program may be selected manually or internally by the MINKEY controller.

Sequence of Events:

If entered automatically by MINKEY controller, go to MANEUVER.

V37E35E

Note: If P20 rendezvous option is not running, P20 Option 4 is activated now.

Flashing MINKEY Rendezvous Option V50N25 Checklist Code 00017

PRO Elects MINKEY automatic rendezvous sequencing.

ENTER Elects manual sequencing.

MANEUVER

Note: P20 (R61) will maintain tracking attitude computations. If the attitude error becomes greater than 10 degrees, the astronaut will be alerted by:

UPLINK ACTY light on

If the tracking attitude error is less than 10 degrees, proceed to TARGETING.

The attitude error is defined as:

P20 Options 0 & 1 — Angular error between the vehicle pointing axis and the LOS to the target with no angular constraint about the pointing vector.

P20 Options 4 & 5 — Angular errors between the actual and desired gimbal angles required to align the vehicle pointing axis along the LOS to the target and constrain the rotation about the pointing vector.

P35 (continued)

VS8E

Request automaneuver execution.

Flashing Desired FDAI angles for

V50N18 automaneuver

OG(R) XXX.XX deg

IG (P) XXX.XX deg

MG (Y) XXX.XX deg

PRO

V06N18 Maneuver in progress

If MINKEY sequence, go to TARGETING when maneuver is completed.

Flashing Maneuver Complete (manual sequence)

V50N18

ENTER Terminates automaneuver routine, go to TARGETING

TARGETING

Flashing Mark Counters (VHF—Optics)

V16N45 TFI (TPM)

MG

MGA

Mark counter is updated by P20, which may be running in the background. MGA is -1 until the final pass through program.

PRO Set Final flag. V32E continues but Final flag is not set. Used when another pass is desired.

Flashing Delta V at TIG (TPM)

V16N45 in Local Vertical Coordinates

PRO X XXX.XX ft/s

MG Y XXX.XX ft/s

PRO Z XXX.XX ft/s

PRO If Final flag is reset, go to previous Flashing V16N45.

Flashing Mark Counter (VHF—Optics)

V16N45 TFI (TPM)

MG

MGA

MGA will be expected MGA at TIG (TP1). If the IMU is not aligned, MGA will be -00002. (For LM solution (P75) MGA is always -00002 on the final pass.)

PRO If Final flag is reset, go to previous Flashing V16N45.

Flashing Mark Counter (VHF—Optics)

V16N45 TFI (TPM)

MG

MGA

MGA will be expected MGA at TIG (TP1). If the IMU is not aligned, MGA will be -00002. (For LM solution (P75) MGA is always -00002 on the final pass.)

PRO If MINKEY controller is active, W-matrix reinitialization is performed and the appropriate burn program is initiated.

If Delta V solution < 7 ft/s, P41 is initiated.

If Delta V solution ≥ 7 ft/s, P40 is initiated.

Flashing V37 Select New Program (manual sequence)
P36-PLANE CHANGE TARGETING (PC) PROGRAM

Purpose:
1. To calculate parameters associated with the plane change (PC) maneuver for Delta V burns.
2. To store the PC target parameters for use by the desired thrusting program.

Assumptions:
1. This program assumes a stored TIG (CSI) by completion of the Coelliptic Sequence Initiation (CSI) program (P32), an uplinked TIG (CSI) or crew loaded TIG (CSI) in N11.
2. If P20 is in operation while this program is in operation, the astronaut may hold at any flashing display and take optics marks, and/or he may allow VHF ranging marks to accumulate.
3. The ISS need not be on to complete updating if desired by the Universal Tracking program (P20).
4. This program is normally used to target a plane change burn between CSI and CDH at the midpoint (90 degrees central angle after TIG (CSI))
5. 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.
6. This program may be selected manually or internally by the MINKEY controller.

Sequence of Events:
If entered automatically by MINKEY controller, go to MANEUVER.

PRO VO6N18 — Maneuver in progress
If MINKEY sequence, go to TARGETING when maneuver is completed.
Flash V50N18
ENTER Terminates automaneuver routine, go to TARGETING

TARGETING
Flash VO6N33
GET of PC Ignition TIG (PC) 000XX h
000XX min
0XX.XX s

V25E to modify TIG.

PRO
Flash Mark Counter (VHF-Optics) XXbXX
V16N45 Time From Ignition TFI (PC) X XbbXX min/s
MGA -00001
Mark Counter is updated by P20 which may be running in the background. MGA is only displayed on the final pass.

PRO Sets Final flag.

If P20 rendezvous option is not running, P20 Option 4 is activated now.
Flashing MINKEY Rendezvous Option
V50N25 Checklist Code 00017

PRO Elects MINKEY automatic rendezvous sequencing.
ENTER Elects manual sequencing.

MANEUVER

PRO
If Manual Sequence, go to Flashing V37.
If MINKEY controller is active, W-matrix reinitialization is performed and Delta V (N81) magnitude is tested:

If DV magnitude = 0, MINKEY initiates P76
If DV magnitude > 0, MINKEY initiates P52 for possible realignment to new orientation to avoid gimbal lock for +X-axis burn. Go to P52 (PC Realign).

Note: Crew may elect to perform a Y-axis RCS burn, if the Delta V is small, to bypass realigning the IMU. This option is available in P52 (PC Realign).

If the IMU is reoriented for a PC maneuver, it is returned to its original orientation by P52 as controlled by the MINKEY sequencer.

Flashing V37 Select New Program (manual sequence)
P37-RETURN TO EARTH

Purpose:

1. This program will compute a return-to-earth trajectory providing the CSM is outside the lunar sphere of influence at the time of ignition.

2. This program computes and displays a preliminary series of parameters based on a conic trajectory and:
   a. Astronaut specified time of ignition.
   b. Astronaut specified maximum change in velocity.
   c. Astronaut specified reentry angle.

   These parameters are:
   a. Time from ignition to reentry.
   b. Reentry inertial velocity.
   c. Reentry flight path angle.
   d. Latitude of splash.
   e. Longitudes of splash.
   f. Delta V (LV).

3. When the initial display is satisfactory to the astronaut, the program recomputes the same data, using applicable perturbations to the conic trajectory, and displays the new values.

4. Upon final acceptance by the astronaut, the program computes and stores the target parameters for return to earth for use by the SPS program (P40) or RCS program (P41).

5. Based upon the specified propulsion system the following are displayed:
   a. Middle gimbal angle at ignition (MGA).
   b. Time of ignition (TIG).
   c. Time from ignition (TFI).

Assumptions:

1. This program assumes that contact with the ground is unavailable, and is completely self-contained.

2. If value of VPRED entered in Noun 80 is less than the minimum required to return to earth, the Delta V required vector will be computed based on a minimum value. If the value entered is greater than the minimum required to return to earth, then the astronaut desired value will be used to compute the Delta V required vector. The computed Delta V required vector will be displayed in Noun 81.

3. The DAP Data Load routine (R03) should be performed prior to completion of this program.

4. The reentry range calculation provided by the AUGE KUGEL routine may be overwritten by a pad loaded single precision erasable.

5. The external Delta V flag is reset during this program to designate to the thrusting program that Lambert steering is to be used.

Sequence of Events:

V37E37E

Flashing GET of RTE Ignition TIG (RTE) 00XX h 00XX min 0XX. XX s

V26E to load desired TIG.

PRO

Flashing Blank VPRED GAMMA E1

V26E to load desired data.

VPRED is the maximum allowable velocity change for RTE. Zero is entered to compute the minimum AV to conserve fuel. See Assumption 2, GAMMA E1 is the desired flight path angle between the inertial velocity vector and the local horizontal at Entry Interface (EI) altitude of 400,000 ft.

PRO

Flashing Impact Latitude Impact Longitude XXX.XX deg (n north) XXX.XX deg (e east)

To change the desired landing site longitude the maximum velocity change (VPRED) input is adjusted. The AGC-calculated minimum Vg is available by keying V06N40 (R2). Increasing this value and entering it (+) into VPRED will move the longitude to the west or (+) to the east. To adjust input parameters, key V32E and recycle to V06N33.

PRO

Flashing Transfer Time from TIG (RTE) to EI 00XX h 00XX min 0XX. XX s

To change transfer time, V32E to recycle to V06N33 and readjust input parameters.

PRO

Flashing Blank VPRED GAMMA E1

VPRED is the predicted inertial velocity at Entry Interface (EI).

PRO

V32E to recycle to V06N33

Flashing Delta V at TIG (RTE) in Local Vertical Coordinates

X XXX.XX ft/s

Y XXX.XX ft/s

Z XXX.XX ft/s

PRO

If first pass through program recycle to Flashing V06N61.

Flashing Option Code (specify propulsion system) 00007

Flashing Propulsion Code (1-SPS, 2—RCS) 0000X

V22E to load desired option.

PRO

Flashing GET of RTE Ignition TIG (RTE) 00XX h 00XX min 0XX. XX s

PRO

Flashing Mark Counter (VHF—Optics) Not meaningful XXXXX m/s

MGA will be the middle gimbal angle at TIG or 000.002 if the IMU is not aligned.

PRO

Flashing V37 Select New Program.
P40—SPS PROGRAM

Purpose:
1. To compute a preferred IMU orientation and a preferred vehicle attitude for an SPS thrusting maneuver and to maneuver the vehicle to the thrusting attitude.
2. To calculate and display the gimbal angles which would result from the present IMU orientation if the vehicle were maneuvered to the preferred vehicle attitude for an SPS thrusting maneuver. The crew is thereby given an opportunity to perform the maneuver with:
   a. The present IMU orientation (not recommended if middle gimbal angle is greater than 45 degrees). If the IMU has not been aligned within the last 3 hours, realignment is desirable.
   b. A new orientation achieved by selection of P52.
3. To control the GnCS during countdown, ignition, thrusting, and thrust termination of a GnCS controlled SPS maneuver.

Assumptions:
1. The target parameters have been calculated and stored in the AGC by prior execution of a prethrusting program.
2. The required steering equations are identified by the prior prethrust program, which either set or reset the external Delta V steering flag. For external Delta V steering, VG is calculated once for the specified time of ignition. Thereafter, both during thrusting and until the crew notifies the AGC trim thrusting has been completed, the AGC updates VG only as a result of compensated accelerometer inputs.
   For Lambert steering, VG is calculated and updated similarly; however, it is also updated periodically by Lambert solutions to correct for changes in the CSM state vector.
3. The TTE clock is set to count to zero at TIG.
4. Engine ignition may be slipped beyond the established TIG if desired by the crew or if integration can not be completed on time.
5. The SPS thrusting program does not monitor the SC control discrete (Channel 31, Bit 15) during thrusting. This means that the AGC will continue to generate engine actuator commands, SPS Engine On discrete, and FIAI angle error needle commands until the AGC solution indicates Engine Off at which time these commands and the Engine On discrete are terminated. However, this program is not written to take into account the situation where control may be taken away from the GNC and then given back, and it is not recommended. In event control is taken away from the GNC, the AGC will only be responsible for computation of position and velocity.
6. The value of Delta V required will be stored in the local vertical coordinate system and is available during this program until average G turn-on by keying in VO6 N81E.
7. The Orbit Parameter Display routine (R30) may be called during this program by keying in V82E.
8. This program may be selected manually or internally by the MINKEY controller.

Sequence of Events:
If entered automatically by MINKEY controller, go to Flashing V50N18. Maneuver to pad burn attitude and check SXT and boresight stars using optics angles on pad.

V37E40E
Flashing Desired FDAI Angles for
V50N18 Automanuever

OG(R) XXX.XX deg
IG(P) XXX.XX deg
MG(Y) XXX.XX deg

Request maneuver to computed burn attitude.

PRO
V06N18 Same as N18 above.
Mannuer is in process; final FDAI angles displayed.

Flashing Same as N18 above.
V50N18 Automanuever is completed.

SCS-GDC aligned to IMU for backup attitude reference.

SPS gimbal drive motors energized.
S/C Control to SCS; SPS servo check and manual drive check performed.
S/C Control to CMC.

PRO
Flashing Same as N18 above.
V50N18 Vehicle is trimmed to burn attitude.

ENTER
Flashing
V50N25 Checklist Code 00204

PRO
V06N40 Time from Ignition/Cutoff (TFI) XXXX.XX min/s Velocity to be Gained (Vg) XXXX.X ft/s Accumulated Velocity (Av) XXXX.X ft/s

DSKY blanks at TIG - 35 seconds, and V06N40 resumes at TIG -30 seconds.
Average G on.

Ullage initiated with THC if required.

Flashing
V50N40 Astronaut approval of ignition requested.

PRO
Ignition approved.
V06N40 Same as N40 above.

Ignition at TIG.
TVC DAP activated.
SPS engine cutoff; burn complete.
TVC DAP off.

Flashing
V16N40 Same as N40 above.

PRO
V16N85 System (body) Coordinates

Flashing

TRIM Vg residuals with THC if required.

PRO
If MINKEY controller is active, P76 is entered.

Flashing
V37 (Manual Sequence)

V82E Request orbital parameter display.

Flashing
V18N44 Apocenter Altitude, Ha XXXX.X nmi Pericenter Altitude, Hp XXXX.X nmi TFF

PRO
Flashing
V37 Select New Program.

Average G off.
P41—RCS PROGRAM

Purpose:
1. Compute a preferred IMU orientation and preferred vehicle attitude for an RCS
   thrusting maneuver and to maneuver the vehicle to this thrusting attitude.
2. Calculate the gimbal angles which would result from the present IMU orientation if
   the vehicle x+ axis were aligned to the thrust vector. The crew is thereby given an
   opportunity to perform the maneuver with:
   a. The present IMU orientation (not recommended if middle gimbal angle is greater
      than 45 degrees). If the IMU has not been aligned within the last 3 hours,
      realignment is desirable.
   b. A new orientation achieved by selection of P52.
3. Provide suitable displays for manual execution of the thrusting maneuver.

Assumptions:
1. The target parameters have been calculated and stored in the AGC by prior
   execution of a prethrusting program.
2. The required steering equations are identified by the prior prethrust program, which
   either set or reset the external Delta V steering flag. For external Delta V steering,
   VG is calculated once for the specified time of ignition. Thereafter, both during
   thrusting and until the crew notifies the AGC that thrusting has been completed, the
   AGC updates VG only as a result of compensated accelerometer inputs.
   For Lambert steering, VG is calculated and updated similarly. However, it is also
   updated periodically by Lambert solutions to correct for changes in the GSM state
   vector.
3. The TTE clock is set to count to zero at TIG.
4. Translation initiation may be skipped beyond the established TIG as desired by the
   crew or if integration cannot be completed on time.
5. The value of Delta V required will be stored in the local vertical coordinate system
   and is available during this program until Average G turn on by keying in V62 NB1E.
6. The Orbit Parameter Display routine (R30) may be called during this program by
   keying in V62 E2.
7. This program may be selected manually or internally by the MINKEY controller.

Sequence of Events:
If entered automatically by MINKEY controller, go to Flashing V60N18.
   Maneuver to pad burn attitude and check SXT and borisight stars using
   optics angles on pad.

V37E41E

Flashing Desired FDAI Angles
V60N18 OGI (R) XXX,XX deg
V60N18 MG (Y) XXX,XX deg

Request maneuver to computed burn attitude.

PRO

V60N18 Same as N18 above.

Automaneuver in process: Final FDAI angles displayed.

Flashing V60N18 Same as N18 above: Maneuver is complete.

ENTER

V16N85 Velocity to be Gained in Control
X XXXX.X ft/s
System (body) Coordinates (Vta)
Y XXXX.X ft/s
Z XXXX.X ft/s

DSKY blanks at TIG -35 seconds and resumes display at TIG -30 seconds.

Average G on at TIG -30 seconds.

Flashing Flash signifies TIG has arrived.
V16N85 Same as N85 above.

Null Vg with THC at TIG.

P41 (continued)

PRO If MINKEY controller is active, P76 is entered.

V82E Request Orbital Parameter display.

Flashing V37 (Manual Sequence)

V16N44 Apocenter Altitude
Flashing XXXX.X ft/s
V16N44 Pericenter Altitude
Flashing XXXX.X ft/s

TF

PRO

Flashing V37 Select New Program.

Average G off.

P47—THRUST MONITOR PROGRAM

Purpose:
1. To monitor vehicle acceleration during a non-GNCS-controlled thrusting maneuver.
2. To display the Delta V applied to the vehicle by this thrusting maneuver.

Assumptions:
1. This program is normally used during rendezvous final phase. If the crew desires to
   do any final phase thrusting maneuvers automatically under GNCS control, they
   must be accomplished via selection of the Transfer Phase Initiation (TPI) program
   (P34) and then the SPS Thrusting program (P40) or the RCS Thrusting program
   (P41).
2. Range, Range Rate, and Theta may be displayed during this program by calling the
   Rendezvous Parameter Display routine No. 1 (R31) with V33E.
3. Range, Range Rate, and Phi may be displayed during this program by calling the
   Rendezvous Parameter Display routine No. 2 (R34) with V38E.
4. V1, H, and H dot may be called by keying in V16 N82E.
5. The Orbit Parameter Display routine may be called during this program by keying in
   V62.
6. This program should be turned on just prior to the planned thrusting maneuver and
   terminated as soon as possible following the maneuver in order to keep errors of bias
   and AVERAGE G at a minimum.

Sequence of Events:

V37E47E

Average G On

Flashing Delta V Accumulated in Control
V16N85 Coordinate System
X XXXX.X ft/s
Y XXXX.X ft/s
Z XXXX.X ft/s

Display of integrated acceleration during thrusting.

OPTIONAL DISPLAYS

V16N62E

V16N82 Magnitude of Inertial Velocity (V1i)
XXX.X ft/s
Rate of Change of Altitude (HIDOT)
XXX.X ft/s
Altitude Above Pad Radius (HI)
XXX.X nm
KEY REL

Flashing Same as N83 above.
V16N83

V63E Rendezvous parameter display at crew option.

Flashing Range of CSM to LM XXX.XX nmi
V16N54 Range Rate XXX.XX ft/s
Angle Between CSM +X Axis and Local Horizontal (Theta)

V65E Rendezvous parameter display at crew option.

Flashing Range of CSM to LM XXX.XX nmi
V16N53 Range Rate XXX.XX ft/s
Angle Between Optics SLOS and the Local Horizontal (PHI)

PRO

Flashing Apocenter Altitude XXX.XX nmi
V16N44 Pericenter Altitude XXX.XX nmi
OPTICS Mode — Manual
MARK

Flashing Checklist Code 000xx
V50N25 Request terminate mark sequence.
MARK REJECT and recycle to Flashing V51 if not satisfactory.

PRO

Flashing Celestial Body Code
V01N71 00—planet, 01/45—star,
46—sun, 47—earth, 50—moon
V21E load correct star code.

PRO If Star Code # 0 and first mark, recycle to Flashing V51.
If Star Code # 0 and second mark, go to Flashing V06N05.

REFSMAT flag set.

V25E to load planet vector.

PRO If first mark, recycle to Flashing V51.

PRO V32E to recycle to start of program.

P51-IMU ORIENTATION DETERMINATION PROGRAM

Purpose:

1. To determine the inertial orientation of the IMU using sightings on two celestial bodies using the scanning telescope or the sextant.

Assumptions:

1. 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 on an orientation as close as possible to the optimum orientation required by future ASC programs.

Sequence of Events:

V37E51E Checklist Code
V50N25 Perform Celestial Body Acquisition

ENTER To Bypass Coarse Align PRO to Flashing V51.

V41N22 Desired Gimbal Angles to
Coarse Align to

No Att light on.
No Att light off when coarse align complete.

Flashing V51 Request mark.

ZERO OPTICS for 15 seconds.

MARK

OPTICS Mode — Manual

V51 Request mark.

MARK REJECT and recycle to Flashing V51 if not satisfactory.

V21E load correct star code.

PRO If Star Code # 0 and first mark, recycle to Flashing V51.
If Star Code # 0 and second mark, go to Flashing V06N05.

REFSMAT flag set.

V25E to load planet vector.

V32E to recycle to start of program.

*Acceptable N05 Limits

STAR/STAR SXT 0.00°
SCT 0.11°

STAR/PLANET SXT 0.16°
SCT 0.21°
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 scanning telescope or sextant.
   a. Preferred Orientation (00001)
      An optimum orientation for a previously calculated maneuver. This orientation must be calculated and stored by a previously selected program or previously uplinked via P27.
   b. Landing Site Orientation (00004)
      \[ X_{SM} = \text{Unit (R_{LS})} \]
      \[ Y_{SM} = \text{Unit (Z_{SM} x X_{SM})} \]
      \[ Z_{SM} = \text{Unit (H_{CSM} x X_{SM})} \]
      where
      The origin is the center of the moon.
      \[ R_{LS} = \text{The position of the most recently defined landing site at time T (align) selected by the astronaut.} \]
      \[ H_{CSM} = \text{The angular momentum vector of the CSM (R_{CSM} x V_{CSM})} \text{ at time T (align) selected by the astronaut.} \]
      The landing site option is used for aligning the CSM and LM stable members to the same orientation prior to LM/CSM separation and prior to LM ascent from the lunar surface.
   c. Nominal Orientation (00002)
      \[ X_{SM} = \text{Unit Y_{SM} x Z_{SM}} \]
      \[ Y_{SM} = \text{Unit (V x R)} \]
      \[ Z_{SM} = \text{Unit (-R)} \]
      where
      \[ R = \text{The geocentric (earth orbit) or selenocentric (lunar orbit) radius vector at time T (align) selected by the astronaut.} \]
      \[ V = \text{The inertial velocity vector at time T (align) selected by the astronaut.} \]
   d. REFSSM (00003)
      The present IMU orientation differs from that to which it was last aligned due to gyro drift. This option realigns the IMU to its previous alignment orientation (REFSSM).

2. To align the IMU to a predetermined orientation suitable for a plane change (PC) maneuver and to realign the IMU after the maneuver to the pre-PC orientation.
\[ X_{SM} = \text{Unit (X_{SM} \cos 45° + Y_{SM} \sin 45°)} \text{ for first maneuver} \]
\[ X_{SM} = \text{Unit (X_{SM} \cos 45° - Y_{SM} \cos 45°)} \text{ for second maneuver} \]
\[ Y_{SM} = \text{Unit (Z_{SM} x X_{SM})} \]
\[ Z_{SM} = \text{Z_{SM}} \]
where subscript '0' refers to the orientation existing before the alignment.

Assumptions:

1. If the CMC Mode switch is in CMC-Accuracy Hold during the Gyro Torquing routine (R58), the DAP will maneuver the vehicle to follow the platform.
2. An option is provided to point the sextant LOS at astronaut or AGC selected stars either manually by crew input or automatically under AGC control.
3. This program may be selected manually or internally by the MINKEY controller in conjunction with the plane change maneuver.

Sequence of Events:

If entered automatically by MINKEY controller, go to PC REALIGN.

V37E52

Flashing Option ID Code 00001 VO4NO8  Alignment Option 0000x
1—preferred, 2—nominal
3—REFSSMAT, 4—landing site

V22E to key in desired alignment option.

PRO To appropriate option.

PC REALIGN

Flashing Gimbal angles which will 00001 result from pulse torque to
OG XXX.XX deg IG XXX.XX deg
MG XXX.XX deg

If MGA is not satisfactory, maneuver vehicle and V32E to recompute N22 angles.

PRO If N22 angles are satisfactory.

Flashing MINKEY Pulse Torque Option V06N22 Checklist Code 00000

ENTER If this is first reorientation maneuver, the pulse torque to PC orientation is
bypassed and MINKEY enters the RCS Burn program (P41). If this is the second reorientation maneuver, alarm 00402 is generated. The platform must
be torqued to its original orientation.

PRO Commence with pulse torquing.

V16N20 Present ICDU Angles OG XXX.XX deg IG XXX.XX deg MG XXX.XX deg

Upon completion of pulse torquing to new orientation, the MINKEY controller will initiate:
1. P41 if pre-plane change burn and if Delta V < 7 ft/s
2. P40 if pre-plane change burn and if Delta V > 7 ft/s
3. P33 if plane-change maneuver completed (second pulse torquing)

LANDING SITE OPTION (00004)

Flashing GET of Landing Site Coordinate 00XXX h V06N34 System T(Align) 000XX min 0XX.XX s

V22E to load desired T(Align).

PRO

Flashing Latitude of Landing Site V06N89 Longitude/2 XX.XXX deg (+ north) XX.XXX deg (+ east)

V22E to load landing site coordinates.

PRO To Preferred Option

NOMINAL OPTION (00002)

Flashing Same as N34 above, except GET of position and
velocity vectors defining nominal coordinate system.

PRO To Preferred Option

PREFERRED OPTION (00001)

Flashing Desired Gimbal Angles for New V06N22 Orientation at Present Vehicle OG XXX.XX deg
IG XXX.XX deg
MG XXX.XX deg

If the new orientation yields gimbal lock, maneuver vehicle and V32E to recompute
(N22) desired gimbal angles.
**Flashing Checklist Code 00013, CMC Mode Switch — FREE {Avoids maneuvering vehicle} — Key in ENTER or PRO.**

**Gyro Torque Only**

**ENTER**

Torques gyros to achieve new orientation (maintains attitude reference).

V16N20 Monitor Gimbal Angles

<table>
<thead>
<tr>
<th>Type</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>OG</td>
<td>XXX.XX deg</td>
</tr>
<tr>
<td>IG</td>
<td>XXX.XX deg</td>
</tr>
<tr>
<td>MG</td>
<td>XXX.XX deg</td>
</tr>
</tbody>
</table>

Go to RECHECK when torquing is complete.

**Coarse Align Only**

**ENTER**

Coarse aligns gimbals to achieve new orientation (lose attitude reference). No Att light ON until coarse align complete. Go to REFSMMAT option when No Att light out.

**REFSMMAT OPTION (00003)**

**Flashing Checklist Code 00015**

*Request Celestial Body acquisition.*

**PRO**
AGC will select two available stars. Use ENTER to specify crew selection of stars.

**MARK SEQUENCE**

**Flashing Checklist Code V50N25**

Request Celestial Body acquisition.

**PRO**
AGC will select two available stars. Use ENTER to specify crew selection of stars.

**CMC Mode Switch — CMC**

**PRO**
For Planet XX = 00; if XX ≠ 00, go to V06N92 display.

**Flashing**

Unit Vector Specifies

V06N88 Planet Position


text continues on the next page
PS3—BACKUP IMU ORIENTATION DETERMINATION PROGRAM

Purpose:
1. To determine the inertial orientation of the IMU using a backup optical device.

Assumptions:
1. This program is identical to PS1 except that R56 is called in place of R53.
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 required by future AGC programs.

Sequence of Events:
V37E53E
Flashing Checklist Code 00015 V5ON25 Perform Celestial Body acquisition.
ENTER To bypass coarse align, PRO to Flashing V06N94.
V41N22 Desired Gimbal Angles to Coarse Align to 0G XXX.XX 0G XXX.XX 0G XXX.XX
No Att light on.
No Att light off when coarse align complete.
Flashing Optics Angle Coordinates V06N94 for Alternate LOS Shaft XXX.XX deg
Trunnion XXX.XX deg
V24E to load LOS coordinates.
PRO
Flashing Request Mark.
V53
ENTER Does alternate LOS mark.
Flashing Checklist Code 00016 V50N25 Terminate Mark Sequence
PRO Key ENTER to reject mark and recycle to Flashing V53.
Flashing Celestial Body Code 000XX
V21E to load star code.
PRO If Star Code # 0 and first mark, recycle to Flashing V06N94.
If Star Code # 0 and second mark, go to Flashing V06N05.
Flashing Unit Vector Specifies X XXX.XX
V06N88 Planet Position Y XXX.XX Z XXX.XX
V25E to load planet vector.
PRO If first mark, recycle to Flashing V06N94.
Flashing Star Angle Difference* V06N05 XXX.XX deg
PRO V32E to recycle to start of program.
Set REFSMMAT flag.
Flashing Select New Program.
V37
*Acceptable NOS Limits

STAR/STAR COAS 0.70°
STAR/PLANET COAS 0.72°

PS4—BACKUP 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 a backup optical device:
   a. Preferred Orientation (00001)
      An optimum orientation for a previously calculated maneuver. This orientation must be calculated and stored by a previously selected program or previously uplinked via P27.
   b. Landing Site Orientation (00004)
      \[ X_{SM} = \text{Unit (} R_{LS} \text{)} \]
      \[ Y_{SM} = \text{Unit (} Z_{SM} \times X_{SM} \text{)} \]
      \[ Z_{SM} = \text{Unit (} H_{CSM} \times X_{SM} \text{)} \]
      where
      \[ R_{LS} = \text{The position of the most recently defined landing site at time T(align) selected by the astronaut.} \]
      \[ H_{CSM} = \text{The angular momentum vector of the CSM (} R_{CSM} \times V_{CSM} \text{) at time T (align) selected by the astronaut.} \]
      The Landing Site option is used for aligning the CSM and LM stable members to the same orientation prior to LM/CSM separation and prior to LM ascent from the lunar surface.
   c. Nominal Orientation (00002)
      \[ X_{SM} = \text{Unit (} Y_{SM} \times Z_{SM} \text{)} \]
      \[ Y_{SM} = \text{Unit (} V \times R \text{)} \]
      \[ Z_{SM} = \text{Unit (} -R \text{)} \]
      where
      \[ R = \text{The geocentric (earth orbit) or selenocentric (lunar orbit) radius vector at time T (align) selected by the astronaut.} \]
      \[ V = \text{The inertial velocity vector at time T (align) selected by the astronaut.} \]
   d. REFSMMAT (00003)
      The present IMU orientation differs from that to which it was last aligned due to gyro drift. This option realigns the IMU to its previous alignment orientation (REFSMMAT).

Assumptions:
1. If the CMC Mode switch is in CMC-Attitude Hold during the Gyro Torquing routine (R55), the DAP will maneuver the vehicle to follow the platform.
2. This program is identical to PS2 except that R56 is called in place of R52 and R53.

Sequence of Events:
V37E54E
Flashing Option ID Code 00001
V04N06 Alignment Option 0000X
1—preferred, 2—nominal, 3—REFSMMAT, 4—landing site.
PRO To appropriate option.
LANDING SITE OPTION (00004)

Flashing GET of Landing Site Coordinate 00XXX h
V06N34 System T(Align) 000.XX min
V25E to load desired T(Align).

Flashing Latitude of Landing Site XX.XXX deg (+ north)
V06N89 Longitude/2 XX.XXX deg (+ east) Altitude XXX.XX nmi
V25E to load landing site coordinates.

To Preferred option.

NOMINAL OPTION (00002)

Flashing Same as N34 above except GET of position and velocity
V06N34 vectors defining nominal coordinate system.

To Preferred option.

PREFERRED OPTION (00001)

Flashing Desired Gimbal Angles for New Orientation at Present Vehicle OG XXX.XX deg
V06N22 IG XXX.XX deg
V22E to recompute (N22) desired gimbal angles.

Flashing Checklist Code 00013,
V50N25 Coarse Align Option
CMC Mode switch – Free (avoids maneuvering vehicle). Key in ENTER or
V16N20 Monitor Gimbal Angles OG XXX.XX deg
CMC Mode Switch — Free
V01N70 IG XXX.XX deg
CMC Mode Switch — Free
V01N83 MG XXX.XX deg
CMC Mode Switch — Free

Go to RECHECK when torquing is complete.

Flashing Checklist Code 00014
V50N25 Fine Alignment Option
CMC Mode Switch — Free
CMC Mode Switch — Free
CMC Mode Switch — Free

MARK SEQUENCE

Flashing Star ID Code 000XX
V01N70 V21E to load star code.

PRO If Star Code # 0, go to Flashing V06N94,
Flashing Unit Vector Specifies
V06N88 Planet Position
V25E to load desired planet vector.

Flashing Optics Angles for Alternate LOS
V06N94 Shaft XXX.XX deg
V24E to load LOS coordinates.

Flashing Checklist Code 00015
V50N25 Terminate Mark Sequence
CMC Mode switch – Free
CMC Mode switch — Free
CMC Mode switch — Free

If alternate LOS mark, recycle to Flashing V53.

Flashing Checklist Code 00016
V06N88 Celestial Body Code of Body Marked On
V21E to correct star code.

Flashing Checklist Code 00017
V06N95 Terminate Mark Sequence
CMC Mode switch — Free
CMC Mode switch — Free
CMC Mode switch — Free

If first mark, recycle to Mark Sequence.

Flashing Checklist Code 00018
V06N96 Star Angle Difference* XXX.XX deg
CMC Mode switch — Free
CMC Mode switch — Free
CMC Mode switch — Free

If NOS unsatisfactory, V32E and go to RECHECK.

Flashing Checklist Code 00019
V06N97 Gyro Torque Angles to Fine Align X XX.XXX deg
CMC Mode Switch — Free
CMC Mode switch — Free
CMC Mode switch — Free

If first mark, recycle to Mark Sequence.

Flashing Checklist Code 00020
V06N98 Fine Alignment Option
CMC Mode switch — Free
CMC Mode switch — Free
CMC Mode switch — Free

Request Celestial Body acquisition.

Flashing Checklist Code 00021
V06N99 Select New Program V37
CMC Mode switch — Free
CMC Mode switch — Free
CMC Mode switch — Free

*Acceptable NOS Limits

STAR/STAR COAS 0.70°
STAR/PLANET COAS 0.72°
P61—ENTRY—PREPARATION PROGRAM

Purpose:
1. To start navigation, check IMU alignment, and provide entry monitor system initialization data.

Assumptions:
1. The program is entered with adequate freefall time to complete the maneuvers from a worst case starting attitude.
2. The ISS is on and precisely aligned to a satisfactory orientation.

Sequence of Events:

V37E61E
Average G On
Flashing Impact Latitude XXX.XX deg
V06N61 Impact Longitude XXX.XX deg
Roll Attitude Code ±0000X
X = +1 — heads up/lift vector down
X = -1 — heads down/lift vector up (normal)

V25E to load entry data.

PRO
Flashing G Max XXX.XX g
V06N60 VPRED XXXXX ft/s
GAMMA EI XXX.XX deg

GMax is the maximum predicted acceleration for ENTRY at nominal bank angle (L/D ratio = 0.18). VPRED is the predicted inertial velocity at Entry Interface (EI) altitude of 400 k ft. GAMMA EI is the flight path angle between the inertial velocity vector and the local horizontal at EI altitude of 400 k ft.

PRO
Flashing RTOGO XXX.XX nmi
V16N63 VIO XXXX ft/s
TFE XXXX min/s

RTOGO is the range to go from a preloaded altitude of 290,626 feet to splash.
This is approximately 0.05 g altitude. VIO is the predicted velocity at 290,626 feet.
TFE is the time until 290,626-foot altitude is reached.

PRO
AGC advances to P62.

P62—ENTRY—CM/SM SEPARATION AND PREENTRY MANEUVER PROGRAM

Purpose:
1. To notify crew when the GNCS is prepared for CM/SM separation.
2. To orient the CM to the correct attitude for atmospheric entry.

Assumptions:
1. The program is entered with adequate freefall time to accomplish CM/SM separation and complete the maneuver from a worst case starting attitude.
2. The IMU is satisfactorily aligned for entry.
3. The program is automatically selected by the Entry—Preparation program (P61) or it may be selected manually.
4. The astronaut may monitor N63 (RTOGO, VIO, TFE) by keying in V16 N63 E.

Sequence of Events:

V37E62E
If entered manually; normally entered automatically from P61.
Average G on. Normally on from P61.
Flashing Checklist Code 00041
V60N25

Perform CM/SM separation.
Maneuver to Separation Attitude.
SC Control to SCS.
CM/SM Separation — On.
Maneuver to Horizon Track Attitude.

PRO
Entry DAP Activated
Flashing Impact Latitude XXX.XX deg
V06N61 Impact Longitude XXX.XX deg
Roll Attitude ±0000X
X = +1 — heads up/lift vector down
X = -1 — heads down/lift vector up (normal)

V25E to load desired data.

PRO
If angle of attack of CM is within 45 degrees of desired, go to P63.
V08N22 Desired Gimbal Angles
OG(R) XXX.XX deg
IG(P) XXX.XX deg
MG(Y) XXX.XX deg

Roll angle depends on heads up/down option. Pitch depends on the desired angle of attack into the atmosphere. When CM is within 45 degrees of desired advance to P63.
AGC Advances to P63.
P63—ENTRY—INITIALIZATION PROGRAM

Purpose:
1. To initialize the entry equations.
2. To continue to hold the CM to the correct attitude with respect to the atmosphere for the onset of entry deceleration.
3. To establish entry DSKY displays.
4. To sense 0.05 g and display this event to the crew by selecting the Entry—Post 0.05 g program (P64).

Assumptions:
1. The program is automatically selected by the Entry—CM/SM Separation and Preentry Maneuver program (P62).

Sequence of Events:
P63 entered automatically from P62.

VO6N64 Drag Acceleration XXX.XX g
Inertial Velocity XXXXX, ft/s
Range to Splash

OPTIONAL DISPLAYS
V16N68 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX, ft/s
Drag Acceleration (G) XXX.XX g

V16N63 Range from EMS Altitude (RTOTARG) XXXX.X nmi
Inertial Velocity at EMS Altitude XXXXX, ft/s
Time to go Until EMS Altitude XXbXX min/s

V16N74 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity XXXXX, ft/s
Drag Acceleration XXX.XX g

Manual track of horizon reduces pitch error needle as pitch attitude approaches the desired angle of attack.
SC Control Switch - CMC/Auto.
Entry DAP now controlling vehicle attitude.
G&N system senses 0.05g drag acceleration.
AGC advanced to P64.

P64—ENTRY—POST 0.05 G PROGRAM

Purpose:
1. To start entry guidance at 0.05 g selecting roll attitude, constant drag level, and drag threshold, KA, which are keyed to the 0.05 g point.
2. Select final phase (P67) when 0.2 g occurs if V < 27,000 ft/s at 0.05 g.
3. Iterate for upcontrol solution (P65) if V > 27,000 ft/s and if altitude rate and drag level conditions are satisfied.
4. Select final phase (P67) if no upcontrol solution exists with VL > 18,000 ft/s.
5. To continue entry DSKY displays.

Assumptions:
1. The program is automatically selected by the Entry—Initialization program (P63).

Sequence of Events:
P64 entered automatically from P63 at 0.05 g.

VO6N74 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX, ft/s
Drag Acceleration (G) XXX.XX g

OPTIONAL DISPLAYS
V16N68 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX, ft/s
Drag Acceleration (G) XXX.XX g

V16N63 Range from EMS Altitude (RTOTARG) XXXX.X nmi
Inertial Velocity at EMS Altitude XXXXX, ft/s
Time to go Until EMS Altitude XXbXX min/s

V16N74 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity XXXXX, ft/s
Drag Acceleration XXX.XX g

AGC advances to P65 or P67.
If VI < 27 k ft/s at 0.05 g, go to P67 when 0.2 g drag is sensed.
If VI > 27 k ft/s, a constant drag trajectory is flown until HDOT becomes more positive than -700 ft/s. A range-to-go check will determine if a controlled skip (P65) phase should be entered. The entry is targeted nominally for a RTOTARG at EI which will be too small to satisfy P65 requirements and P67 is entered at this point.
P65—ENTRY—UPCONTROL PROGRAM

Purpose:
1. To execute Entry—Upcontrol guidance which steers the CM to a controlled exit (skip out) condition.
2. To establish Entry—Upcontrol displays which are used in conjunction with the EMS to determine for the astronaut if the backup procedures should be implemented.
3. To sense exit (drag acceleration less than 0.07 ft/s²) and thereupon to select the Entry—Ballistic Phase program (P66).
4. Where HDOT is negative and the V is sufficiently low (V-VL-C18 neg), the program will exit directly to P67 (Final Phase).

Assumptions:
1. This program is automatically selected by the Entry—Post 0.05 g program (P64) when constant drag control has brought range prediction to within 25 nmi of the desired range. It is skipped in earth orbit missions.

Sequence of Events:
P65 entered automatically from P64.

Flashing: Commanded Bank Angle (Beta) XXX.XX deg
V16N67 Drag Level at Skipout (DL) XXX.XX g
Skipout Velocity (VL) XXX.XX ft/s

PRO Manual response to N67 is not necessary to terminate P65. Selection of P66 or P67 by entry guidance provides automatic termination.

V06N74 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX ft/s
Drag Acceleration (G) XXX.XX g

OPTIONAL DISPLAYS
V16N64E Drag Acceleration (G) XXX.XX g
Inertial Velocity (VI) XXXXX ft/s
Range-to-Splash (RTOTARG) XXXX X nmi

V16N68E Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX ft/s
Altitude Rate (HDOT) XXXX ft/s

V16N74E Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX ft/s
Drag Acceleration (G) XXX.XX g

AGC advances to P66 or P67.
P67 will be entered when HDOT is negative and the velocity is sufficiently low. P66 will be entered when exit is sensed.

P66-ENTRY—BALLISTIC PROGRAM

Purpose:
1. To maintain CM attitude during ballistic (skip out) phase for atmospheric reentry.
2. To sense reentry (drag acceleration builds up to 0.07 + 0.5 ft/s² or approximately 0.2 g) and thereupon to select the Entry—Final Phase program (P67).

Assumptions:
1. This program is automatically selected by the Entry—Upcontrol program (P65) when drag acceleration becomes less than 0.07 ft/s².

Sequence of Events:
P66 is entered automatically from P65.
V06N22 Desired Gimbal Angles OG XXX.XX deg
V16N64 Drag Level at Orient the Vehicle to IG XXX.XX deg
Correct Angle of Attack MG XXX.XX deg

Three-axis control of S/C is regained when acceleration falls below 0.05 g and is relinquished when the drag increases above this value.

OPTIONAL DISPLAYS
V16N64E Drag Acceleration (G) XXX.XX g
Inertial Velocity (VI) XXXXX ft/s
Range to Splash (RTOTARG) XXXX X nmi

V16N68E Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX ft/s

V16N74E Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXX ft/s
Drag Acceleration (G) XXX.XX g

AGC advances to P67.
P67 is entered at reentry or when approximately 0.2 g is sensed.
P67—ENTRY—FINAL PHASE PROGRAM

Purpose:
1. To continue entry guidance after Q7F + 0.5 ft/s² (or approximately 0.2 g) until termination of steering when the CM velocity WRT earth = 1,000 ft/s (altitude is approximately 65,000 ft).
2. To continue entry DSKY displays.

Assumptions:
1. The program is automatically selected by:
   a. P65 when HDOT is negative and the V is sufficiently low (V-VL-C18 neg).
   b. P66 when drag acceleration builds up to Q7F + 0.5 ft/s² for approximately 0.2 g.
   c. P64 if no upcontrol solution exists with VL > 18,000 ft/s.

Sequence of Events:
P67 is entered automatically from P64, PGS, or P6G.

OPTIONAL DISPLAYS

V06N66 Commanded Bank Angle (Beta) XXX.XX deg
Crossrange Error XXXXX.X nmi (+ south)
Downrange Error XXXXX.X nmi (+ overshoot)

V16N64 Drag Acceleration (G) XXX.XX g
Inertial Velocity (VI) XXXXXX. ft/s
Range-to-Splash (RTOTARG) XXXXX. nmi

V16N68 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXXX. ft/s
Altitude Rate (HDOT) XXXXX. ft/s

V16N74 Commanded Bank Angle (Beta) XXX.XX deg
Inertial Velocity (VI) XXXXXX. ft/s
Drag Acceleration (G) XXX.XX g

Relative velocity reaches 1,000 ft/s

V06N67 Range-to-Splash (RTOTARG) XXXXX.X nmi (+ overshoot)
V16N67 Present Latitude XXXXX.X deg (+ north)
V16N67 Present Longitude XXXXX.X deg (+ east)

SC Control—SCS
Prevent jet firings when Drogue chutes deploy.

PRO
Flashing V37 Select New Program.
Average G off.

P72—LM COELLIPTIC SEQUENCE INITIATION (CSI) PROGRAM

Purpose:
1. To calculate parameters associated with the following concentric flight plan maneuvers for LM execution of the maneuvers under the control of the LGC: the Coelliptic Sequence Initiation (CSI) and the Constant Delta Altitude maneuver (CDH).
2. To calculate these parameters based upon maneuver data approved and keyed into the AGC by the astronaut.
3. To display to the astronaut and the ground dependent variables associated with the concentric flight plan maneuvers for approval by the astronaut/ground.

Assumptions:
1. At a selected TPI 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 LM 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 horizontal plane defined by the active vehicle position at CSI ignition.
6. The pericenter altitude of the orbit following CSI and CDH must be greater than 36,000 feet (lunar orbit) or 85 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 CSM orbit. However, out-of-plane parameters are computed for TIG(CSI) and displayed. In addition, the N81 display is modified to establish an antinode at CSI.
8. If P20 is in operation while this program is operating, the astronaut may hold at any flashing display and take optics marks, and/or he may allow VHF ranging marks to accumulate.
9. The ISS need not be on to complete this program unless automatic state vector updating is desired by the Universal Tracking program (P20).

Sequence of Events:
V37E72E
This sequence is identical to the P32 manual sequence when entered at TARGETING. Record maneuver parameters and transmit to LM.
P73—LM 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 LM execution of the maneuvers under control of the LGC. The concentric flight plan maneuvers are the Coelliptic Sequence Initiation (CSI), the Constant Delta Altitude maneuver (CDH), the Transfer Phase Initiation (TPI), and the Transfer Phase Final (TPF) or braking maneuver.
2. To calculate these parameters based upon maneuver data approved and keyed into the AGC by the astronaut.
3. To display to the astronaut and the ground dependent variables associated with the concentric flight plan maneuvers for approval by the astronaut/ground.

Assumptions:
4. The program is based upon previous completion of the Coelliptic Sequence Initiation (CSI) program (P72). Therefore:
   a. At a selected TPI time the line of sight between the LM and the CSM was selected to be a prescribed angle (E) from the horizontal plane defined at the active vehicle 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 TPI ignition was computed to be greater than 10 minutes.
   d. The variation of the altitude difference between the orbits was minimized.
   e. The CSI burn was defined such that the impulsive Delta V was in the horizontal plane defined by the active vehicle position 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 CSM orbit; however, out-of-plane parameters are computed for TIG(CDH) and displayed. In addition, a vector display is modified to establish an antinode at CDH.
5. If P20 is in operation while this program is operating, the astronaut may hold at any flashing display and take optics marks, and/or he may allow VHF ranging marks to accumulate.

Sequence of Events:
V37E73E
This sequence is identical to the P33 manual sequence when entered at TARGETING. Record maneuver parameters and transmit to LM.

P74—LM TRANSFER PHASE INITIATION (TPI) TARGETING PROGRAM

Purpose:
1. To calculate the required Delta V and other initial conditions required by the LGC for LM execution of the Transfer Phase Initiation maneuver, given:
   a. Time of ignition (TIG(TPI)) or the elevation angle (E) of the LM/CSM LOS at TIG(TPI).
   b. Central angle of transfer (CENTANG) from TIG(TPI) to intercept time TIG(TPF).
2. To display to the astronaut and the ground certain dependent variables associated with the maneuver for approval by the astronaut/ground.

Assumptions:
1. The program must be done over a tracking station for real-time ground participation in AGC data input and output.
2. If P20 is in operation while this program is operating, the astronaut may hold at any flashing display and take optics marks, and/or he may allow VHF ranging marks to accumulate.
3. 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 VO6 N52.
4. 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.
5. The ISS need not be on to complete this program unless automatic state vector updating is desired by the Universal Tracking program (P20).

Sequence of Events:
V37E74E
This sequence is identical to the P34 manual sequence when entered at TARGETING. Record maneuver parameters and transmit to LM.
**P75—LM TRANSFER PHASE MIDCOURSE (TPM) TARGETING 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. If P20 is in operation while this program is operating, the astronaut may hold at any flashing display and take optics marks, and/or he may allow VHF ranging marks to accumulate.

2. 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.

3. The time of intercept (T(INT)) was defined by previous completion of the LM Transfer Phase Initiation (TP) program (P74) and is presently available in AGC storage.

4. There is no requirement for ISS operation during this program unless automatic state vector updating is desired by the Universal Tracking program (P20).

**Sequence of Events:**

V37E75E

This sequence is identical to the P35 manual sequence when entered at TARGETING. Record maneuver parameters and transmit to LM.

**P76—TARGET DELTA V PROGRAM**

**Purpose:**
1. To provide a means of notifying the AGC that the LM has changed its orbital parameters by the execution of a thrusting maneuver.
2. To provide to the AGC the Delta V applied to the LM to enable an updating of the LM state vector.

**Assumptions:**
1. The CSM crew has the Delta V to be applied by the LM in local vertical axis at a specified TIG. These values are displayed prior to TIG by the Freethrust Targeting program in the LM. No provision is made in these thrusting programs to display the results of the maneuver in a form usable by this routine, if the burn is not nominal and this Delta V is not as specified or if TIG is not as originally specified, consult backup procedures.
2. In the event of an uplink failure, the astronaut can create a reasonable LM state vector for LM insertion into orbit from the lunar surface by keeping in the expected LM thrusting maneuver from the lunar surface while the surface flag is set. This will cause the computer to take the position vector of the landing site and add the input Delta V and store the results in the LM state vector. The landing site will not be altered.
3. This program may be selected manually or internally by the MINKEY controller.

**Sequence of Events:**

If entered automatically by the MINKEY controller, go to Flashing V06N33.

V37E76E

Flashing Time of ignition of LM thrusting maneuver TIG

TIG is loaded with CSM calculated TIG from targeting program V25E to modify TIG.

PRO

Flashing Delta V of LM at TIG in X XXXX X ft/s

V06N84 Local Vertical Coordinates

N84 is loaded with the negative of the CSM targeting solution, modified for out-of-plane velocity (VYDOT). IF CSM actually did burn, N84 is loaded with zero.

V25E to modify Delta V.

PRO

If manual sequence, go to Flashing V37

If MINKEY sequence, the next targeting program in the rendezvous sequence is initiated. The maneuver sequence is:
1. Multiple Coeliptic Sequence Initiation (CSI) maneuvers (P32),
2. Height Adjust (HAM) maneuver (P31),
3. Final Coeliptic Sequence Initiation (CSI) maneuver (P32),
4. Plane change (PC) maneuver (P36),
5. Constant Delta Altitude (CDH) maneuver (P33),
6. Transfer Phase Initiation (TPIM) maneuver (P34),
7. Transfer Phase Midcourse (TPM) number one maneuver (P35),
8. Transfer Phase Midcourse (TPM) number two maneuver (P38),

*If P76 is entered after the PC maneuver and an IMU PC reorientation was performed, MINKEY returns to P52 for a realignment of the IMU to its original orientation prior to selection of the CDH targeting program.

Flashing

V37 Select new program (manual sequence)
P72: CSM TARGET DELTA V PROGRAM

Purpose:
1. To provide a means of notifying the CSM that CSM has changed its initial parameters by the execution of a thruster maneuver with AV/200.<br>2. To notify the CSM the Delta V applied to the CSM to enable an update of the CSM state vector.

Assumptions:
1. The crew has the Delta V applied to the CSM in its local coordinate at a specified T0.<br>2. AV/200 should be performed after AV/7 to update AV.<br>3. The contents of NV1 are the same as the previous value at D+7.

Sequence of Events:

| V007-74 | Flashing | AV/200 in which Delta V was executed | 08:XX:XX h | 00:XX:XX min | SXX.X X
| V007-29 | Flashing | Delta V executed in | V0051 | X | XXXX X X
| V007-29 | Flashing | Delta V executed in | V0051 | Z | XXXX X X
| V007-29 | Flashing | Select New Program |

P77: FINAL RENDEZVOUS PROGRAM

Purpose:
1. To establish X-axis tracking by AV/200.
2. To select the rendezvous parameter display (P041) internally to provide range and range rate information prior to the rendezvous sequence.

Assumptions:
1. This program may be selected manually or internally by the MINKEY controller.

Sequence of Events:

| V007-39 | Flashing | If entered automatically by MINKEY controller, go to MANEUV.
| V007-39 | Flashing | Note: If P041 rendezvous option is not memory, P041 Option 1 selected next.
| MANEUV | Note: P041 rendezvous option is not memory, P041 Option 1 selected next.

P92: ICSI Targeting

1. Start rendezvous navigation (P041) Option 4, with optics tracking assumed, maneuver to track attitude, and enable VHF ranging and state vector updating.
2. Perform CSM targeting computations.
3. Inhibit rendezvous navigation.
4. Select a burn program.
5. Update LM orbital parameters (P76) for LM thrusting maneuver.
6. Select final coelliptic sequence initiation targeting (P32).

P38: PC Targeting

1. Start rendezvous navigation (P041), maneuver to track attitude, and enable VHF ranging and state vector updating.
2. Assess PC targeting parameters.
3. Inhibit rendezvous navigation.
4. Plane change realignment options:
   a. If PC Delta V < 0, go to ICS Targeting Step 7.
   b. If PC Delta V > 0, select IMU Realignment (P52) program:
      1. If X-axis thrusting desired, realign IMU to PC orientation to avoid gimbal lock and go to selection of burn program, Step 6.
      2. If X-axis thrusting desired, IMU realignment is bypassed and ACS burn program (P41) is selected.
5. Select a burn program* (P41 selected if Y axis RCS used).
6. Reorient IMU to original orientation prior to PC realign and maneuver to LM tracking attitude (only if IMU realignment was performed).
7. Update LM orbital parameters (P76) for LM thrusting maneuver.
8. Select Constant Delta Altitude targeting (P33).

P33 (CDH Targeting)
1. Start rendezvous navigation (P20), maneuver to tracking attitude, and enable VHF tracking and state vector updating.
2. Perform CDH targeting computations.
3. Inhibit rendezvous navigation.
4. Select a burn program*.
5. Update LM orbital parameters (P76) for LM thrusting maneuver.
6. Select Transfer Phase Initiation targeting (P34).

P34 (TP1 Targeting)
1. Start rendezvous navigation (P20), maneuver to tracking attitude, and enable VHF tracking and state vector updating.
2. Perform TP1 targeting computations.
3. Inhibit rendezvous navigation.
4. Select a burn program*.
5. Update LM orbital parameters (P76) for LM thrusting maneuver.
6. Select Transfer Phase Midcourse targeting (P35).

P35 (TPM Targeting)
1. Start rendezvous navigation (P20), maneuver to tracking attitude, and enable VHF tracking and state vector updating.
2. Perform TPM targeting computations and reinitialize W matrix.
3. Inhibit rendezvous navigation.
4. Select a burn program*.
5. Update LM orbital parameters (P76) for LM thrusting maneuver.
6. Test for completion of midcourse correction (MCC) maneuver.
   a. If MCC-1 just completed, return to TPM targeting (P36) for MCC-2 maneuver computations.
   b. If MCC-2 just completed, go to final rendezvous (P79).

P79 (Final Rendezvous)
1. Start rendezvous navigation (P20), maneuver to X-axis tracking attitude, and enable VHF tracking and state vector updating.
2. Activate rendezvous parameters display (R31) of range, range rate, and theta.
3. Exit MINKEY autosequencing and manually select new program.

*Automatic selection of a burn program (P40/P41) is based upon the Delta V solution computed in the targeting program:
1. If Delta V < 7 ft/s, the RCS Burn (P41) program is selected.
2. If Delta V ≥ 7 ft/s, the SPS Burn (P40) program is selected.
MINIMINKEY. Reduction in the number of key strokes during P23 can be accomplished by inverting REFSMFLG after star-horizontal acquisition and first mark. A successive pass through P23 will bypass the acquisition and maneuver displays and will go directly to the marking display after the optics calibration is bypassed.

Digital Event Timer. An erasable procedure is proposed to make use of the DSKY as a backup event timer.

Inertial Subsystem (CEP 101-199)

CMC Operation with the IMU Cage Discrete Failed-On. In the event of a cage discrete failure with an uncaged IMU, normal autopilot operation can be resumed by reinitializing IMODES33 and resetting IMODES33 Bit 6.

CMC Operation with ISS Turn-On Discrete Failure. To be determined.

CMC Operation with IMU Operate Discrete Failed-Off. To be determined.

Inhibit T4RUPT Coarse Alignment of IMU Because of Runaway ZCDU During Coasting Flight. In the event a ZCDU failure causes an apparent global lock condition, the automatic coarse align mode can be inhibited by setting AVEGFLAG and loading the Saturn vehicle configuration in R1 of N46. This procedure preserves the use of the IMU as an inertial reference but precludes use of the digital autopilots.

P40 Termination During AVERAGEG When EMP 509 is Operating. When EMP 509 is running, this procedure is available to facilitate use of P40, P41 thruster programs without interference with the coarse align inhibiting. The status of AVEGFLAG is maintained while P40 and AVERAGEG are terminated correctly.

P40 Operation Using GDC REFSMMAT. In the event the IMU is disabled, a REFSMMAT can be computed for the GDC orientation. Loading of N20 with GDC angles and proper initiation of P51 logic enables onboard computation of REFSMMAT for GDC orientation.

CMC Direct Ascent Rendezvous Timeline with IMU Failed. To be determined.

VHF Ranging (CEP 201-299)

Display of VHF Range on DSKY During P79. In the event the EMS range counter should fail during rendezvous final phase, a means is available for backup range display on the DSKY. By enabling state vector updates during P79, the range marks can be monitored as they are taken. A possible waiting N49 display will terminate further marks until the waiting display is responded to.

VHF Range Display on DSKY. The raw VHF range data may be displayed anytime the range marking system is active by monitoring the associated erasable location.
CEP 203 Manual VHF Range Input. Should the automatic VHF range marking become disabled, a method is available for manually inputting range marks. The range mark address is loaded with a future value of range. When the loaded value of range is reached, as determined from the EMS range counter, the erasable program is activated and the range mark is processed.

Refer to EMP 515.

Optics Subsystem (301-399)

CEP 301 P52 with Frozen Optics. Cancelled.

CEP 302 Landmark Tracking with Failed Mark Button. If mark/mark reject switch failures should occur, an erasable program is available which makes use of the PRO/ENTR keys to perform normal landmark track (P24) marking.

Refer to CSM G&C checklist G3-16, EMP 501.

CEP 303 Use of COAS Variance Instead of the SXT Variance in R22. Increased uncertainty in mark data, due to a degraded IMU or optics, or when GDC data is used, can be compensated for by using the COAS variance (ALTVAR) rather than the SXT variance (XTVAR).

Refer to EMP 504.

CEP 304 Marking with Failed Mark Button. Interrupt processing of the NAV DSKY key inputs also results in storage of the mark data. Normal mark logic can be activated by a waitlist call to routine MARKDIF in the event of an open failure of the MARK switch. Closed failures of the MARK switch merely require depression of a NAV DSKY key which is interpreted as a MARK.

Refer to EMP 505.

CEP 305 Landmark Tracking Using Frozen Optics. Assuming the CDUs are still good, the immobile optics shaft and trunnion angles are used to convert the Optics LOS pointing vector to vehicle coordinates and is computed by the ground or by EMP 517. The coordinates are then loaded in N78 to point the LOS at the landmark. Following initial acquisition the landmark is tracked manually with the vehicle using minimum impulse control and normal P24 marking is performed.

Refer to CSM G&C checklist G3-2, EMP 508.

CEP 306 Landmark Tracking Using COAS. P24 landmark tracking using the COAS is done by manually tracking the landmark with minimum impulse control of the vehicle. Marking is done using an erasable program which uses N94 alternate LOS coordinates for optics angles, and uses the PRO/ENTR keys for marking/mark reject.

Refer to CSM G&C checklist G3-1B, EMP 500.

CEP 307 P52 with Frozen Optics. Assuming the CDUs are good, P20 is used to point the optics LOS at the desired celestial body. The optics LOS in vehicle coordinates (N78) is computed on the ground or by EMP 517.

CEP 308 CMC Optics Mode Override. Same as CEP 003.

CEP 309 P40 with Failed Optics CDU. To be determined.

CEP 310 Optics Shaft and Trunnion Angles Converted to Body Angles. This erasable program converts the optics LOS vector from shaft and trunnion optic coordinates to P20 pointing vector coordinates, gamma, rho and loads them in N78.

Refer to EMP 517.

CEP 311 Alignments with Failed OODU. IMU alignment programs P51/P52 can be performed with a failed OCDU by altering the mark data in the failed axis with the TPAC angle read at the time of marking.

Refer to Colossus memo 332.

CEP 312 SPS Gimbal Drive Test Directly by V31. In order to avoid executing P30/P40 to perform an SPS gimbal drive test, this procedure does a waitlist call to that portion of P40 which executes the gimbal drive test.