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_8 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. Initializes 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 (continued)

Sequence of Events:

P02 entered automatically from P01.

Vertical erect for 640 seconds, then gyrocompass.

V78E Optional entry if launch azimuth change is desired.

Flashing V06N29	XSM Launch Azimuth	XXX.XX deg

V21E. Enter new launch azimuth.

Vertical erect for 320 seconds, then gyrocompass.

V75E Optional at Liftoff if automatic Liftoff discrete is not received.

AGC advances to P11 at liftoff.

P03—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.

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. In order to prematurely terminate this program and return to P02 the astronaut may key in V34E on any flashing display.

Sequence of Events:

Zero Optics for 15 seconds.

V65E

P03 displayed.

Flashing V06N41	Target Azimuth Target Elevation Target ID	XXX.XX deg XX.XXX deg 00001

Target 1 coordinates.

V24E. Change azimuth and elevation if desired.

PRO

Flashing V06N41	Target Azimuth Target Elevation Target ID	XXX.XX deg XX.XXX deg 00002

Target 2 coordinates.

V24E. Change azimuth and elevation if desired.

Optics Mode – CMC.

PRO

CMC drives optics LOS to Target 1.

Flashing V51

Optics to Manual – Mark on Target 1.

Flashing V50N25	Checklist Code	00016

Request terminate Mark sequence.

P03 (continued)

MARK REJECT (If mark was unsatisfactory), and recycle to Flashing V51.

PRO (if mark was satisfactory), and continue.

CMC drives optics LOS to Target 2.

Flashing V51

Optics to Manual – Mark on Target 2.

Flashing V50N25	Checklist Code	00016

Terminate mark sequence.

MARK REJECT (If mark was unsatisfactory), and recycle to previous Flashing V51.

PRO (If mark was satisfactory), and continue.

Flashing V06N93	Alignment Error In Delta Gyro Angles	X XX.XXX deg Y XX.XXX deg Z XX.XXX deg

Displays Y_{SM} and X_{SM} leveling error and X_{SM} azimuth error.
V24E to zero Y and X leveling errors.

PRO Torques Z gyro to eliminate azimuth error.

V34E Terminates optical verification and returns to P02.

P06—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 (V37EXXE), a terminate (V34E), or an ENTER in response to the request for standby.

Sequence of Events:

V37E06E

Flashing V50N25	Checklist Code	00062

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.

Flashing V37

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 FDAI 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 SIVB. 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.

V06N62	Inertial Velocity Magnitude	XXXXX. ft/s
	Altitude Rate	XXXXX. ft/s
	Altitude	XXXX.X nmi

Pitch/roll polynomial start at liftoff +10.97 seconds.

Terminate polynomial at liftoff +155.22 seconds.

V82E Orbital parameter display.

Flashing V16N44	Apogee Altitude	XXXX.X nmi
	Perigee Altitude	XXXX.X nmi
	TFF	XXbXX min/s

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	00XXX h
		000XX 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	Time From TLI Ignition (TFI)	XXbXX min/s
	Velocity to be Gained (Vg)	XXXXX. ft/s
	Velocity Magnitude (VMAGI)	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). XXbXX min/s
S-IVB cutoff discrete issued when VI C/O attained.

Flashing V16N95	Same as N95 above but TFC display frozen.

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.

P20 (continued)

Sequence of Events:

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

V37E20E

Flashing V04N06	Option ID Code	00024
	Tracking Option Code	0000X

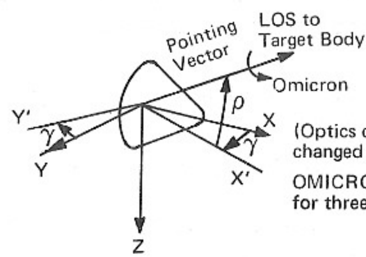
V22E to Load desired option:
0 = Rendezvous (VECPOINT)
1 = Celestial body (VECPOINT)
2 = Rotation (PTC/ORB rate)
4 = Rendezvous (Three-axis)
5 = Celestial body (Three-axis)
(Option 4 assumed for MINKEY rendezvous)

PRO

Flashing V06N78	GAMMA	XXX.XX deg
	RHO	XXX.XX deg
	OMICRON	XXX.XX deg

V25E 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.



SIMBAY pointing	= 90°, 52.25°
COAS pointing	= 0°, 0°
Optics pointing	= 0°, -35°
PTC rotation	= 0°, 0°
Orb rate rotation	= 90°, 0°

(Optics coordinates are assumed for rendezvous but may be changed at anytime.)

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

PRO

Flashing V06N79	Desired Rate (Option 2 only)	X.XXXX deg/s
	Desired Deadband	XXX.XX deg

V24E to Load desired rate and deadband.

PRO to appropriate option

CELESTIAL BODY TRACK

Flashing V01N70	Star ID Code	000XX

V21E to load desired Star Code.

PRO If Star Code ≠ 00, Go to MANEUVER

Flashing V06N88	Unit position vector of desired planet	X .XXXXX
		Y .XXXXX
		Z .XXXXX

V25E to load position vector.

PRO to MANEUVER

P20 (continued)

ROTATION

Flashing V06N34	GET at which rotation maneuver is to start	00XXX h 000XX min 0XX.XX s

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

PRO to TERMINATE (rotation will commence at specified GET)

RENDEZVOUS

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.

V58E

Request automaneuver execution.

Flashing V50N18	Desired FDAI angles for automaneuver	OG(R) IG (P) MG (Y)	XXX.XX deg XXX.XX deg XXX.XX deg

PRO

V06N18	Maneuver in progress
Flashing V50N18	Maneuver Complete

ENTER Terminates automaneuver routine. If rendezvous 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 327.67 nmi.

V87E Sets VHF Range Flag manually.
Enables ranging marks for use by R22 at 1-minute intervals.

V88E Resets VHF Range Flag manually.
Disables ranging marks. Use V87E to reenable.

BACKUP COAS MARKING

V54E Calls the backup sighting mark routine.

Flashing V06N94	Optics angle coordinates for alternate LOS (COAS)	Shaft Trunnion	XXX.XX deg XX.XXX deg

V24E to load coordinates.

COAS LOS coordinates can be determined by sighting on a boresight star and using P52 to compute the desired optics angles to acquire the star in the SXT field.

PRO

Flashing V53N45	MARK Counter (VHF - Optics) TFI of Next Burn MGA at TIG	XXbXX XXbXX min/s XXX.XX deg
	TFI and MGA are computed by targeting program, if running.	

ENTER Used for marking with COAS. V86E is used to reject a backup mark.

Note: N78 may be modified to specify +X axis pointing for COAS marking at any time. The program will calculate a maneuver to +X axis tracking attitude.

P20 (continued)

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 V06N49	Delta R Delta V Source Code (1–OPT, 2–VHF)	XXX.XX nmi XXXX.X ft/s 0000X

PRO Uses 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 freefall from the present time until T Lat Long.

Sequence of Events:

V37E21E

Flashing V04N06	Option Code (specify vehicle)	00002
	Vehicle Code (1–CSM, 2–LM)	00001

CSM is assumed; if LM is desired, V22E2E

PRO

Flashing V06N34	Time Lat/Long	00XXX. h 000XX. min 0XX.XX s

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

PRO

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

V32E recycles to Flashing V06N34 for new display.

V06N73E Optional Display

Flashing V06N73	Altitude Velocity Flight Path Angle	XXXXXb nmi XXXXX. ft/s 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. Calculate 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 its 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. Store 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 optics SLOS at the chosen landing site and mark it once, (at least one mark on the primary landmark must have been 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 GNC free mode.
   c. Automatic pitchover maneuver via P20, Option 2.
8. Selection of this program will terminate Options 0 and 4 of P20.

Sequence of Events:

V37E22E

Flashing V06N45	Maximum MGA with Spacecraft X Axis in Orbital Plane	(R3)	XXX.XX deg

If expected MGA is greater than 60 degrees, exit P22 and realign IMU (P52).

P22 (continued)

ZERO Optics for 15 seconds.

OPTICS Mode – CMC

PRO If in earth orbit go to Flashing V06N89 below.

Flashing V05N70	Landmark Code (R2)	ABCDE

A=1 (known landmark), 2 (unknown landmark)
B = index of offset indicator
C = not used
DE = Landmark ID (00, 01, or 5X)

V22E to Load LMK Code

PRO If A = 2, Optics mode to manual and to go Flashing V51; If A = 1 and DE ≠ 00, go to Flashing V06N92.

Flashing V06N89	Landmark Latitude Longitude/2 Altitude of LMK	XX.XXX deg XX.XXX deg XXX.XX nmi

V25E. Load landmark coordinates.

PRO

V06N92 Auto position optics to landmark or, if DE = 5X, to 60 degrees ahead of vehicle location on ground track.

Maneuver vehicle at orbital rate for tracking.

OPTICS Mode – Manual

Flashing V51

Request marks.

MARK

Offset landing site mark followed by V52E.

Flashing V50N25	Checklist Code	00016 (After five marks taken)

PRO Terminate mark sequence.

Flashing V05N71	Same as N70 above.	ABCDE

V22E to correct data.

(Insure B corresponds to the mark on offset landing site or is set to zero.)

PRO

Flashing V06N89 Same as N89 above.

V25E to correct data.

PRO

Flashing V06N49	Delta R Delta V	XXX.XX nmi XXXX.X ft/s

Change in position and velocity magnitudes with incorporation of landmark sighting.

PRO Accepts data. V32E to reject data and recycle to Flashing V05N70.

Flashing V06N89 Same as N89 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 redo 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, R1 = 0 to 37 (octal), R2 = ABCDE, C = 1 or 2, R3 = ABCDE, C and D = 1 or 2). Noun 89 is also 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 V50N25 — Checklist Code — 00015

Perform celestial body acquisition.

PRO If manual acquisition desired, key ENTER and go to Flashing V59.

Flashing V01N70 — Star ID Code — 000XX

V21E to load star code XX.

PRO If star ID ≠ 00, go to Flashing V50N18.

Flashing V06N88 — Unit Position Vector of Planet — X .XXXXX, Y .XXXXX, Z .XXXXX

V25E to load planet vector.

PRO

Flashing V50N18 — Desired FDAI Angles for Automaneuver — OG(R) XXX.XX deg, IG(P) XXX.XX deg, MG(Y) XXX.XX deg

OPTICS ZERO for 15 seconds

OPTICS Mode – Manual

PRO Automaneuver LLOS to selected star.

V06N18 — Maneuver in process.

Flashing V50N18 — Maneuver complete.

ENTER

Terminate maneuver routine.

Flashing V59 — Request optics calibration mark.

To bypass optics calibration, key ENTER and go to Flashing V05N70.

P23 (continued)

MARK

LLOS and SLOS superimposed on star.

Flashing V06N87 — Trunnion Bias — (R2) XX.XXX deg

Mark may be repeated for additional bias computations.

PRO V32E will recycle to Flashing V50N25.

Flashing V05N70 — Star ID Code 000XX; Landmark ID ABCDE; Horizon ID 00FG0

V25E to load desired data.

ABDE = not used
C = 1 (earth landmark), 2 (lunar landmark)
F = 1 (earth horizon), 2 (lunar horizon)
G = 1 (near horizon), 2 (far horizon)

(if R2 ≠ 0, R3 = 0) or (if R2 = 0, R3 ≠ 0)

PRO If PLANET/HOR sighting, go to Flashing V06N88.
If STAR/HOR sighting, go to Flashing V50N25.

Flashing V06N89 — Latitude of Landmark XX.XXX deg; Longitude/2 XX.XXX deg; Altitude XXX.XX nmi

V25E to load landmark coordinates.

PRO If STAR/LMK sighting, go to Flashing V50N25.

Flashing V06N88 — Unit Planet Vector — X .XXXXX, Y .XXXXX, Z .XXXXX

V25E to load planet vector.

PRO

Flashing V50N25 — Checklist Code — 00202

Request automaneuver LLOS to LMK/HOR.

PRO Specifies a 3-axis maneuver. ENTER may be used to specify VECPOINT computed maneuver.

Flashing V50N18 — Same as N18 above. Request automaneuver.

PRO

V06N18 — Same as N18 above. Maneuver in process.

Flashing V50N18 — Same as N18 above. Maneuver complete.

A V94E may be used to reacquire the landmark with an automaneuver.

OPTICS Mode – CMC

ENTER

Terminate automaneuver and autoposition.
Optics SLOS to the selected STAR/PLANET.

V06N92 — Desired Optics Angles — Shaft XXX.XX deg, Trunnion XX.XXX deg

OPTICS Mode – Manual

Flashing V51 — Request Mark (STAR/PLANET and LMK/HOR superimposed).

MARK

Flashing V50N25 — Checklist Code — 00016

P23 (continued)

PRO Terminate mark sequence.

Flashing V05N71	Same as N70 above.

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	Same as N88 above.

V25E to correct planet vector.

PRO State vector update computed.

Flashing	Delta R	XXX.XX nmi
V06N49	Delta V	XXXX.X ft/s

Magnitude of the position and velocity vector changes displayed for astronaut approval.

PRO Accept data. V32E reject data, go to Flashing V37.

Flashing V37	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	XX.XXX 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 V51	AGC will now compute optics drive rates to maintain 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 V37	Select New Program

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 V04N06	Option ID Code Vehicle Option (1–CSM, 2–LM)	00002 0000X

V22E to load desired vehicle code.

PRO

Flashing V06N34	GET at which CMC begins search (all 0's for present time)	00XXX h 000XX 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 by specified vehicle	00XXX h 000XX min 0XX.XX s

PRO V32E to previous flashing V06N43 to change longitude.

Flashing V06N43	Latitude at Longitude Crossing Longitude Specified Altitude of Vehicle at Longitude Crossing	XXX.XX deg XXX.XX deg XXXX.X 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 V06N33	Ground Elapsed Time of Ignition (TIG)	00XXX. h 000XX. min 0XX.XX s

V25E to load desired TIG.

PRO

Flashing V06N81	Impulsive Delta V at TIG in Local Vertical Coordinates	X Y Z	XXXX.X ft/s XXXX.X ft/s XXXX.X ft/s

V25E to load desired Delta V.

PRO

Flashing V06N42	Apogee/Apolune Altitude Perigee/Perilune Altitude Magnitude of Delta V at TIG	XXXX.X nmi XXXX.X nmi XXXX.X ft/s

PRO

Flashing V16N45	Mark Counter (VHF—Optics) Time from Ignition (TFI) Middle Gimbal Angle at TIG with Vehicle +X Axis in Direction of Thrust	XXbXX marks XXbXX min/s XXX.XX deg

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 Delta V 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 Delta V is selected to minimize the variation of the altitude difference between the orbits.
3. HAM burn is defined such that the impulsive Delta V 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 Delta V flag is set during this program to designate to the thrusting program that external Delta V steering is to be used.
10. This program may be selected manually or internally by the MINKEY controller.

P31 (continued)

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 V50N25	MINKEY Rendezvous Option 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.

V58E

Request automaneuver execution.

Flashing V50N18	Desired FDAI angles for automaneuver	OG(R) IG (P) MG (Y)	XXX.XX deg XXX.XX deg XXX.XX deg

PRO

V06N18 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 V06N11	GET of CSI Ignition TIG (CSI)	00XXX h 000XX min 0XX.XX s

V25E to load desired TIG.

PRO

Flashing V06N55	Apsidal Crossing Elevation Angle CENTANG	0000X XXX.XX deg XXX.XX deg

V25E to load desired data.
Apsidal 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 ≠ 0 specifies TIG (CDH) to occur at N (180) degrees from CSI maneuver and N = number entered in R1.

P31 (continued)

PRO

Flashing V06N37	GET of TPI Ignition TIG (TPI)	00XXX h 000XX min 0XX.XX s

V25E to modify TIG.

PRO

Flashing V06N33	GET of HAM Ignition TIG (HAM)	00XXX h 000XX min 0XX.XX s

V25E to modify TIG.

PRO

Flashing V16N45	Mark Counter (VHF-Optics) Time from Ignition TFI (HAM) MGA	XXbXX XXbXX min/s -00001

Mark counter updated by P20 which is running in the background.
MGA 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 00600 through 00606 may occur. If an alarm occurs, V32E recycles to V06N11 where the INPUT parameters may be adjusted for a new solution.

Flashing V06N90	Out-of-Plane Position (Y), Active Vehicle Out-of-Plane Velocity (YDOT), Active Vehicle Out-of-Plane Velocity (YDOT), Passive Vehicle	XXX.XX nmi XXXX.X ft/s XXXX.X ft/s

PRO

Flashing V06N81	Delta V at TIG (HAM) In Local Vertical Coordinates	X Y Z	XXXX.X ft/s XXXX.X ft/s XXXX.X ft/s

V25E to modify Delta V.

PRO If Final flag not set go to previous flashing V16N45

Flashing V16N45	Mark Counter (VHF-Optics) TFI (HAM) MGA	XXbXX XXbXX min/s XXX.XX deg

MGA will be the MGA at TIG (HAM). 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)

P32—CSM COELLIPTIC SEQUENCE INITIATION (CSI) PROGRAM

Purpose:

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

Assumptions:

1. At a selected 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 paralled to the plane of the LM 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 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 designate to the thrusting 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.

Flashing V50N25	MINKEY Rendezvous Option 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.

P32 (continued)

V58E

Request automaneuver execution.

Flashing V50N18	Desired FDAI angles for automaneuver	OG(R) IG (P) MY (P)	XXX.XX deg XXX.XX deg XXX.XX deg

PRO

V06N18 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 V06N11	GET of CSI Ignition TIG (CSI)	00XXX h 000XX min 0XX.XX s

V25E to load desired TIG.

PRO

Flashing V06N55	Apsidal Crossing Elevation Angle CENTANG	0000X XXX.XX deg XXX.XX deg

V25E to load desired data.

Apsidal 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)

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

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

PRO

Flashing V06N37	GET of TPI Ignition TIG (TPI)	00XXX h 000XX min 0XX. XX s

V25E to load desired TIG.

PRO

Flashing V16N45	Mark Counter (VHF—Optics) Time from Ignition TFI (CSI) MGA	XXbXX XXbXX min/s -00001

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)

PRO 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 V06N11 where the input parameters may be adjusted for a new solution.
If automatic MINKEY sequence, go to flashing V06N90.

Flashing V06N75	Delta Altitude at TIG (CDH)	XXXX.X nmi
	Delta Time of TIG (CSI/CDH)	XXbXX min/s
	Delta Time of TIG (CDH/TPI)	XXbXX min/s

TIG (CDH) is available by keying V06N13E.

PRO

Flashing V06N90	Out-of-Plane Position (Y) Active Vehicle	XXX.XX nmi
	Out-of-Plane Velocity (YDOT) Active Vehicle	XXXX.X ft/s
	Out-of-Plane Velocity (YDOT) Passive Vehicle	XXXX.X ft/s

PRO

Flashing V06N81	Delta V at TIG (CSI)	X	XXXX.X ft/s
	In Local Vertical Coordinates	Y	XXXX.X ft/s
		Z	XXXX.X ft/s

PRO If automatic MINKEY sequence, go to Flashing V16N45.

Flashing V06N82	Delta V at TIG (CDH)	X	XXXX.X ft/s
	In Local Vertical Coordinates	Y	XXXX.X ft/s
		Z	XXXX.X ft/s

PRO

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

Flashing V16N45	Mark Counter (VHF–Optics)	XXbXX
	TFI (CSI)	XXbXX min/s
	MGA	XXX.XX deg

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.)

PRO

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

If Delta V solution $\lessdot$ 7 ft/s, P41 is initiated.
If Delta V solution $\gtrdot$ 7 ft/s, P40 is initiated.

Flashing
V37 Select New Program (manual sequence)

P33—CSM 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 paralled to the plane of the LM orbit. However, out-of-plane parameters are computed for TIG (CDH) and displayed. In addition, the N81 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. This 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 V50N25	MINKEY Rendezvous Option	
	Checklist Code	00017

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

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.

P33 (continued)

V58E

Request automaneuver execution.

Flashing V50N18	Desired FDAI angles for automaneuver	OG (R) IG (P) MG (Y)	XXX.XX deg XXX.XX deg XXX.XX deg

PRO

V06N18 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 (CDH)	00XXX h 000XX min 0XX. XX s

V25E to correct desired TIG.

PRO

Flashing V16N45	Mark Counter (VHF–Optics) Time from Ignition TFI (CDH) MGA	XXbXX XXbXX min/s -00001

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.
If an Alarm occurs, a V32E may be used to recycle to V06N13 and readjust TIG.
If automatic MINKEY sequence, go to Flashing V06N90.

Flashing V06N75	Delta Altitude at TIG (CDH) Delta Time of TIG (CDH/TPI) Delta Time of TIG (TPI/Nom TPI)	XXXX.X nmi XXbXX min/s XXbXX min/s

TIG (TPI) is available by keying V06N37E.

PRO

Flashing V06N90	Out-of-Plane Position (Y) Active Vehicle Out-of-Plane Velocity (YDOT) Active Vehicle Out-of-Plane Velocity (YDOT) Passive Vehicle	XXX.XX nmi XXXX.X ft/s XXXX.X ft/s

PRO

Flashing V06N81	Delta V at TIG (CDH) in Local Vertical Coordinates	X Y Z	XXXX.X ft/s XXXX.X ft/s XXXX.X ft/s

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

Flashing V16N45	Mark Counter (VHF–Optics) TFI (CDH) MGA	XXbXX XXbXX min/s 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 $\leq$7 ft/s, P41 is initiated.
If Delta V solution $\geq$7 ft/s, P40 is initiated.

Flashing
V37 Select New Program (manual sequence)

P34—CSM TRANSFER PHASE INITIATION (TPI) TARGETING PROGRAM

Purpose:

1. To calculate the required Delta V and other initial conditions required by the AGC for execution of the Transfer Phase Initiation maneuver. Given:
   a. TIG (TPI) or the Elevation angle (E) of the CSM/LM LOS at TIG (TPI).
   b. Central angle of transfer (CENTANG) from TIG (TPI) to intercept time (TIG(TPF)).
2. To calculate TIG (TPI) given E or E given TIG (TPI).
3. To store the TPI target parameters for use by the desired thrusting program.

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 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.
4. When determining the initial position and velocity of the target at intercept time, either conic or precision integration may be used. The time difference for computation is approximately 10:1 (that is, conic integration is 10 times faster than precision integration).
5. ISS need not be on to complete this program unless automatic state vector updating is desired by the Universal Tracking program.
6. The external Delta V flag is reset during this program to designate to the thrusting program that Lambert steering is to be used.
7. The Delta V in LOS coordinates is available in N59.
8. This program may be selected manually or internally by the MINKEY controller.

P34 (continued)

Sequence of Events:

If entered automatically by MINKEY controller, go to MANEUVER.

V37E34E

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

Flashing V50N25	MINKEY Rendezvous Option 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 FDAI angles for automaneuver	OG(R) IG (P) MG (Y)	XXX.XX deg XXX.XX deg XXX.XX deg

PRO

V06N18 Maneuver in progress

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

Flashing V50N18 Maneuver Complete (manual sequence)

ENTER Terminate automaneuver routine, go to TARGETING

TARGETING

Flashing V06N37	GET of TPI Ignition TIG (TPI)	00XXX h 000XX min 0XX.XX s

V25E to correct desired TIG.

PRO

Flashing V06N55	Number of Precision Offsets Elevation Angle CENTANG	0000X XXX.XX deg XXX.XX deg

V25E 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/LM LOS and the CSM local horizontal at TIG (TPI). E should = +00000 if E is to be computed at TIG specified. (For LM solution (P74) the angle is between the LM/CSM LOS and the LM local horizontal.)

CENTANG is the orbital angle traversed by the passive vehicle from TIG (TPI) to time of intercept.

PRO

Flashing V16N45	Mark Counter (VHF—Optics) TFI (TPI) MGA at TIG (TPI)	XXbXX XXbXX min/s -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 Set Final flag. V32E continues in program but Final flag is not set. Used when another pass is desired.

P34 (continued)

COMPUTE ELEVATION ANGLE FOR GIVEN TIG.
If elevation angle above was = 0,

Flashing V06N55 Same as N55 above, except elevation angle has been computed.

COMPUTE TIG FOR GIVEN ELEVATION ANGLE. If elevation angle above was ≠ 0,

Flashing V06N37	Time of Ignition for Specified Elevation Angle TIG (TPI)	00XXX h 000XX min 0XX.XX 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 V06N58	Pericenter Altitude (Post-TPI) Delta V Required for TPI Delta V Required for TPF	XXXX.X nmi XXXX.X ft/s XXXX.X ft/s

PRO

Flashing V06N81	Delta V at TIG (TPI) in Local Vertical Coordinates	X XXXX.X ft/s Y XXXX.X ft/s Z XXXX.X ft/s

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

Flashing V16N45	Mark Counter (VHF—Optics) TFI (TPI) MGA	XXbXX XXbXX min/s XXX.XX deg

MGA will be the expected MGA at TIG (TPI). If the IMU is not aligned, MGA will be -00002. (For LM solution (P74), 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)

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 (T(INT) was defined by previous completion of the Transfer Phase Initiation (TPI) program (P-34) 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 V50N25	MINKEY Rendezvous Option 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)

V58E

Request automaneuver execution.

Flashing V50N18	Desired FDAI angles for automaneuver	OG(R) IG (P) MG (Y)	XXX.XX deg XXX.XX deg XXX.XX deg

PRO

V06N18 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 V16N45	Mark Counters (VHF—Optics) TFI (TPM) MGA	XXbXX XXbXX min/s -00001

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 V06N81	Delta V at TIG (TPM) in Local Vertical Coordinates	X Y Z	XXXX.X ft/s XXXX.X ft/s XXXX.X ft/s

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

Flashing V16N45	Mark Counter (VHF—Optics) TFI (TPM) MGA	XXbXX XXbXX min/s XXX.XX deg

MGA will be expected MGA at TIG (TPI). 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 $\geq$ 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 this progam unless automatic state vector updating is 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.

V37E36E

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

Flashing V50N25	MINKEY Rendezvous Option 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.

V58E

Request automaneuver execution.

Flashing V50N18	Desired FDAI angles for automaneuver	OG(R) IG (P) MG (Y)	XXX.XX deg XXX.XX deg XXX.XX deg

P36 (continued)

PRO

V06N18	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 V06N33	GET of PC Ignition TIG (PC)	00XXX h 000XX min 0XX.XX s

V25E to modify TIG.

PRO

Flashing V16N45	Mark Counter (VHF-Optics) Time From Ignition TFI (PC) MGA	XXbXX XXbXX min/s -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.

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

Flashing V06N90	Out-of-Plane Position (Y) CSM Out-of-Plane Velocity (YDOT) CSM Out-of-Plane Velocity (YDOT) LM	XXX.XX nmi XXXX.X ft/s XXXX.X ft/s

PRO

Flashing V06N81	Delta V at TIG (PC) In Local Vertical Coordinates	X XXXX.X ft/s Y XXXX.X ft/s Z XXXX.X ft/s

V25E to modify Delta V.

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

Flashing V16N45	Mark Counter (VHF-Optics) TFI (PC) MGA	XXbXX XXbXX min/s XXX.XX deg

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

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. Longitude 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 60 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 over-written 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.

P37 (continued)

Sequence of Events:

V37E37E

	Flashing V06N33	GET of RTE Ignition TIG (RTE)	00XXX h 000XX min 0XX.XX s

V25E to load desired TIG.

PRO	Flashing V06N60	Blank VPRED GAMMA EI	— XXXXX. ft/s XXX.XX deg

V25E to load desired data.

VPRED is the maximum allowable velocity change for RTE. Zero is entered to compute the minimum ΔV to conserve fuel. See Assumption 2, GAMMA EI 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 V06N61	Impact Latitude Impact Longitude	XXX.XX deg (+ north) XXX.XX deg (+ 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 (-) west or (+) east. To adjust input parameters, key V32E and recycle to V06N33.

PRO	Flashing V06N39	Transfer Time from TIG (RTE) to EI	00XXX h 000XX min 0XX.XX s

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

PRO	Flashing V06N60	Blank VPRED GAMMA EI	— XXXXX ft/s XXX.XX deg

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

PRO V32 to recycle to V06N33

	Flashing V06N81	Delta V at TIG (RTE) in Local Vertical Coordinates	X XXXX.X ft/s Y XXXX.X ft/s Z XXXX.X ft/s

PRO If first pass through program recycle to Flashing V06N61.

	Flashing V04N06	Option Code (specify propulsion system) Propulsion Code (1–SPS, 2–RCS)	00007 0000X

V22E to load desired option.

PRO	Flashing V06N33	GET of RTE Ignition TIG (RTE)	00XXX h 000XX min 0XX.XX s
PRO	Flashing V16N45	Mark Counter (VHF–Optics) TFI (RTE) MGA	Not meaningful XXbXX min/s XXX.XX deg

MGA will be the middle gimbal angle at TIG or -00002 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 FDAI attitude 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 GNCS and then given back, and it is not recommended. In event control is taken away from the GNCS, 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 V06 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 V50N18	Desired FDAI Angles for Automaneuver	OG(R) IG(P) MG(Y)	XXX.XX deg XXX.XX deg XXX.XX deg

Request maneuver to computed burn attitude.

P40 (continued)

PRO

V06N18	Same as N18 above.	

Maneuver is in process; final FDAI angles displayed.

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

ENTER

Flashing V50N25	Gimbal Slew Test Option. Checklist Code	 00204

PRO Slews SPS gimbal ±2 degrees; ENTER – Bypasses gimbal slew test.

SPS gimbals commanded to trim angles (P, Y)

V06N40	Time from Ignition/Cutoff (TFI) Velocity to be Gained (Vg) Accumulated Velocity (ΔV)	XXbXX min/s XXXX.X ft/s 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 V99N40	Same as N40 above at TIG -5 seconds. 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

Flashing V16N85	Vg Residuals in Control System (body) Coordinates	X XXXX.X ft/s Y XXXX.X ft/s Z XXXX.X ft/s

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 V16N44	Apocenter Altitude, Ha Pericenter Altitude, Hp TFF	XXXX.X nmi XXXX.X nmi XXbXX min/s

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 the 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 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. Translation initiation may be slipped beyond the established TIG if 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 V06 N81E.
6. The Orbit Parameter Display routine (R30) may be called during this program by keying in V82E.
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 V50N18. Maneuver to pad burn attitude and check SXT and boresight stars using optics angles on pad.

V37E41E

Flashing V50N18	Desired FDAI Angles	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.

Automaneuver in process; final FDAI angles displayed.

Flashing V50N18 Same as N18 above. Maneuver is complete.

ENTER

V16N85	Velocity to be Gained in Control System (body) Coordinates (Vg)	X	XXXX.X ft/s
		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 V16N85 Flash signifies TIG has arrived. Same as N85 above.

Null Vg with THC at TIG.

P41 (continued)

PRO If MINKEY controller is active, P76 is entered.

Flashing V37 (Manual Sequence)

V82E Request Orbital Parameter display.

Flashing V16N44	Apocenter Altitude	XXXX.X ft/s
	Pericenter Altitude	XXXX.X ft/s
	TFF	XXbXX min/s

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 V83E.
3. Range, Range Rate, and Phi may be displayed during this program by calling the Rendezvous Parameter Display routine No. 2 (R34) with V85E.
4. VI, H, and H-dot may be called by keying in V16 N62E.
5. The Orbit Parameter Display routine may be called during this program by keying in V82E.
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 V16N83	Delta V Accumulated in Control 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

V16N62	Magnitude of Inertial Velocity (VI)	XXXXX. ft/s
	Rate of Change of Altitude (HDOT)	XXXXX. ft/s
	Altitude Above Pad Radius (H)	XXXX.X nmi

P47 (continued)

KEY REL

	Flashing V16N83	Same as N83 above.	

V83E Rendezvous parameter display at crew option.

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

PRO

V85E Rendezvous parameter display at crew option.

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

PRO

V82E Orbital parameter display.

	Flashing V16N44	Apocenter Altitude	XXXX.X nmi
		Pericenter Altitude	XXXX.X nmi
		TFF	XXbXX min/s

PRO

	Flashing V16N83	Same as N83 above.

PRO

	Flashing V37	Select New Program.

Average G off.

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 at an orientation as close as possible to the optimum orientation required by future AGC programs.

P51 (continued)

Sequence of Events:

V37E51E

	Flashing V50N25	Checklist Code		00015
		Perform Celestial Body Acquisition		

ENTER To Bypass Coarse Align PRO to Flashing V51.

	V41N22	Desired Gimbal Angles to Coarse Align to	OG	000.00 deg
			IG	000.00 deg
			MG	000.00 deg

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

	Flashing V51	Request mark.

ZERO OPTICS for 15 seconds.

OPTICS Mode – Manual

MARK

	Flashing V50N25	Checklist Code	00016
		Request terminate mark sequence.	

MARK REJECT and recycle to Flashing V51 if not satisfactory.

PRO

	Flashing V01N71	Celestial Body Code 00–planet, 01/45–star, 46–sun, 47–earth, 50–moon	000XX

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.

	Flashing V06N88	Unit Vector Specifies Planet Position	X	.XXXXX
			Y	.XXXXX
			Z	.XXXXX

V25E to load planet vector.

PRO If first mark, recycle to Flashing V51.

	Flashing V06N05	Star Angle Difference*	XXX.XX deg

PRO V32E to recycle to start of program.

REFSMMAT flag set.

	Flashing V37	Select New Program.

*Acceptable N05 Limits

STAR/STAR	SXT	0.03°
	SCT	0.11°
STAR/PLANET	SXT	0.18°
	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 the 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} = Unit (R_{LS})

      Y_{SM} = Unit $(Z_{SM} \times X_{SM})$

      Z_{SM} = Unit $(H_{CSM} \times X_{SM})$

      where

      The origin is the center of the moon.

      R_{LS} = The position of the most recently defined landing site at time T(align) selected by the astronaut.

      H_{CSM} = The angular momentum vector of the CSM $(R_{CSM} \times V_{CSM})$ 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} = Unit $(Y_{SM} \times Z_{SM})$

      Y_{SM} = Unit $(V \times R)$

      Z_{SM} = Unit $(-R)$

      where

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

      V = the inertial velocity vector at time T (align) selected by the astronaut.

   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).

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} = Unit $(X_{SMO} \cos 45^\circ + Y_{SMO} \sin 45^\circ)$ for first maneuver

   X_{SM} = Unit $(X_{SMO} \cos 45^\circ - Y_{SMO} \cos 45^\circ)$ for second maneuver

   Y_{SM} = Unit $(Z_{SM} \times X_{SM})$

   $Z_{SM} = Z_{SMO}$

   where subscript '0' refers to the orientation existing before the alignment.

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. 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.

P52 (continued)

Sequence of Events:

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

V37E52

Flashing V04N06	Option ID Code		00001
	Alignment Option		0000X
	1–preferred, 2–nominal 3–REFSMMAT, 4–landing site		

V22E to key in desired alignment option.

PRO To appropriate option.

PC REALIGN

Flashing V06N22	Gimbal angles which will result from pulse torque to PC orientation	OG IG MG	XXX.XX deg XXX.XX deg XXX.XX deg

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

PRO If N22 angles are satisfactory.

Flashing V50N25	MINKEY Pulse Torque Option Checklist Code	00020

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 IG MG	XXX.XX deg XXX.XX deg 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 $\geqslant$ 7 ft/s
3. P33 if plane-change maneuver completed (second pulse torque)

LANDING SITE OPTION (00004)

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

V25E to load desired T(Align).

PRO

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

V25E to load landing site coordinates.

PRO To Preferred Option

NOMINAL OPTION (00002)

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

PRO To Preferred Option

PREFERRED OPTION (00001)

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

If the new orientation yields gimbal lock, maneuver vehicle and V32E to recompute (N22) desired gimbal angles.

P52 (continued)

PRO

Flashing V50N25	Coarse Align Option 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	OG IG MG	XXX.XX deg XXX.XX deg XXX.XX deg

Go to RECHECK when torquing is complete.

Coarse Align Only

PRO 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 V50N25	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 V01N70	Star ID Code		000XX

V21E to key in star code.

ZERO OPTICS for 15 seconds.

OPTICS Mode – CMC

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

Flashing V06N88	Unit Vector Specifies Planet Position	X Y Z	.XXXXX .XXXXX .XXXXX

V25E to specify desired planet vector.

PRO

V06N92	Desired Optics Angles	Shaft Trunnion	XXX.XX deg XX.XXX deg

CMC drives optics LOS to target.

OPTICS Mode – Manual

Flashing V51	Request Mark.

Mark on Target

Flashing V50N25	Checklist Code		00016

Terminate Mark Sequence option.

P52 (continued)

PRO Marking was okay, if not MARK REJECT.

Flashing V01N71	Star ID Code of Body Marked On		000XX

V21EXXE if not correct.

PRO If Star Code ≠ 0 and first MARK, recycle to MARK SEQUENCE.
If Star Code ≠ 0 and second MARK, go to Flashing V06N05.

Flashing V06N88	Same as N88 above.

V25E to correct planet vector.

PRO If first MARK recycle to MARK SEQUENCE.

Flashing V06N05	Star Angle Difference*		XXX.XX deg

If N05 not satisfactory, V32E, and go to RECHECK.

PRO

Flashing V06N93	Gyro Torque Angles to Fine Align	X Y Z	XX.XXX deg XX.XXX deg XX.XXX deg

CMC Mode Switch – Free (Avoids maneuvering vehicle when torquing gyros).

PRO Torque gyros. V32E to bypass gyro torquing.

RECHECK

Flashing V50N25	Checklist Code Fine Alignment Option		00014

PRO Recycles to REFSMMAT option for check on alignment.

ENTER

Flashing V37	Select New Program.

*Acceptable N05 Limits

STAR/STAR	SXT	0.03°
	SCT	0.11°
STAR/PLANET	SXT	0.18°
	SCT	0.21°

P53–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 P51 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 V50N25	Checklist Code Perform Celestial Body acquisition.		00015

ENTER To bypass coarse align, PRO to Flashing V06N94.

V41N22	Desired Gimbal Angles to Coarse Align to	OG IG MG	XXX.XX XXX.XX XXX.XX

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

Flashing V06N94	Optics Angle Coordinates for Alternate LOS	Shaft Trunnion	XXX.XX deg XX.XXX deg

V24E to load LOS coordinates.

PRO

Flashing V53 — Request Mark.

ENTER
Does alternate LOS mark.

Flashing V50N25	Checklist Code Terminate Mark Sequence	00016

PRO Key ENTER to reject mark and recycle to Flashing V53.

Flashing V01N71	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 V06N88	Unit Vector Specifies Planet Position	X Y Z	.XXXXX .XXXXX .XXXXX

V25E to load planet vector.

PRO If first mark, recycle to Flashing V06N94.

Flashing V06N05	Star Angle Difference*	XXX.XX deg

PRO V32E to recycle to start of program.
Set REFSMMAT flag.

Flashing V37 — Select New Program.

*Acceptable N05 Limits

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

P54–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} = Unit (R_{LS})

   Y_{SM} = Unit ($Z_{SM} \times X_{SM}$)

   Z_{SM} = Unit ($H_{CSM} \times X_{SM}$)

   where

   The origin is the center of the moon.

   R_{LS} = The position of the most recently defined landing site at time T(align) selected by the astronaut.

   H_{CSM} = The angular momentum vector of the CSM ($R_{CSM} \times V_{CSM}$) 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} = Unit ($Y_{SM} \times Z_{SM}$)

   Y_{SM} = Unit ($V \times R$)

   Z_{SM} = Unit (-R)

   where

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

   V = The inertial velocity vector at time T (align) selected by the astronaut.

   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 P52 except that R56 is called in place of R52 and R53.

Sequence of Events:

V37E54E

Flashing V04N06	Option ID Code Alignment Option 1–preferred, 2–nominal, 3–REFSMMAT, 4–landing site.	00001 0000X

PRO To appropriate option.

P54 (continued)

LANDING SITE OPTION (00004)

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

V25E to load desired T(Align).

PRO

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

V25E to load landing site coordinates.

PRO To Preferred option.

NOMINAL OPTION (00002)

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

PRO To Preferred option.

PREFERRED OPTION (00001)

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

If the new orientation yields gimbal lock, maneuver vehicle and V32E to recompute (N22) desired gimbal angles.

PRO

Flashing V50N25	Checklist Code Coarse Align Option	00013

CMC Mode switch — Free (avoids maneuvering vehicle). Key in ENTER or PRO

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

V16N20	Monitor Gimbal Angles	OG IG MG	XXX.XX deg XXX.XX deg XXX.XX deg

Go to RECHECK when torquing is complete.

PRO Coarse aligns gimbal to achieve new orientation (loses attitude reference).

No Att light - on.
No Att light - off when coarse align is complete, go to REFSMMAT option.

REFSMMAT OPTION (00003)

Flashing V50N25	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 V01N70	Star ID Code	000XX

V21E to load star code.

P54 (continued)

PRO If Star Code ≠ 0, go to Flashing V06N94.

Flashing V06N88	Unit Vector Specifies Planet Position	X Y Z	.XXXXX .XXXXX .XXXXX

V25E to load desired planet vector.

PRO

Flashing V06N94	Optics Angles for Alternate LOS	Shaft Trunnion	XXX.XX deg XX.XXX deg

V24E to load LOS coordinates..

PRO

Flashing V53 — Request Mark

ENTER
Does alternate LOS mark.

Flashing V50N25	Checklist Code Terminate Mark Sequence	00016

PRO Key ENTER to reject MARK and recycle to Flashing V53.

Flashing V01N71	Celestial Body Code of Body Marked On	000XX

V21E to correct star code.

PRO If Star Code ≠ 0 and first mark, recycle to Mark Sequence.
If Star Code ≠ 0 and second mark, go to Flashing V06N05

Flashing V06N88 — Same as N88 above.

V25E to correct planet vector.

PRO If first mark, recycle to Mark Sequence.

Flashing V06N05	Star Angle Difference*	XXX.XX deg

PRO If N05 unsatisfactory, V32E and go to RECHECK.

Flashing V06N93	Gyro Torque Angles to Fine Align	X Y Z	XX.XXX deg XX.XXX deg XX.XXX deg

CMC Mode Switch — Free

(Avoids maneuvering vehicle when torquing gyros.)

PRO Torques gyros. (V32E to bypass gyro torquing.)

RECHECK

Flashing V50N25	Checklist Code Fine Alignment Option	00014

PRO Recycles to REFSMMAT option for check on alignment.

ENTER
Terminate Program

Flashing V37 — Select New Program

*Acceptable N05 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 V06N61	Impact Latitude	XXX.XX deg
	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 V06N60	G Max	XXX.XX g
	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 V16N63	RTOGO	XXXX.X nmi
	VIO	XXXXX. ft/s
	TFE	XXbXX 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.

RTOGO and VIO may be used for EMS initialization if pad values not available.

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 V50N25	Checklist Code	00041

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 V06N61	Impact Latitude	XXX.XX deg
	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.

V06N22	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.

V06N64	Drag Acceleration	XXX.XX g
	Inertial Velocity	XXXXX. ft/s
	Range to Splash	XXXX.X nmi (+ is overshoot)

OPTIONAL DISPLAYS

V16N68E

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

V16N63E

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

V16N74E

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.

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

OPTIONAL DISPLAYS

V16N64E

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

V16N68E

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

AGC advances to P65 or P67.

If VI $\leq$ 27 k ft/s at 0.05 g, go to P67 when 0.2 g drag is sensed.
If VI $\geq$ 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 RTOGO 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 Q7 ft/s^2) 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 V16N69	Commanded Bank Angle (Beta)	XXX.XX deg
	Drag Level at Skipout (DL)	XXX.XX g
	Skipout Velocity (VL)	XXXXX. ft/s

PRO Manual response to N69 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

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

V16N68E

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

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 Q7 + 0.5 ft/s^2 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 Q7 ft/s^2.

Sequence of Events:

P66 is entered automatically from P65.

V06N22	Desired Gimbal Angles	OG	XXX.XX deg
	to 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

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

V16N68E

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

V16N74E

V16N74	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/s^2 (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/s^2 (or 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, P65, or P66.

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

OPTIONAL DISPLAYS

V16N64E

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

V16N68E

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

V16N74E

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

Relative velocity reaches 1,000 ft/s

Flashing	Range-to-Splash (RTOTARG)	XXXX.X nmi (+ overshoot)
V16N67	Present Latitude	XXX.XX deg (+ north)
	Present Longitude	XXX.XX 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 35,000 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:

1. This 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, the N81 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).

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 calculate TIG(TPI) given E or E given TIG(TPI).
3. 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 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.
4. When determining the initial position and velocity of the target at intercept time, either conic or precision integration may be used. The time difference for computation is approximately 10:1 (that is, conic integration is 10 times faster than precision integration).
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 (TPI) 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 axes at a specified TIG. These values are displayed prior to TIG by the Prethrust 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 keying 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 inputted 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 V06N33	Time of ignition of LM thrusting maneuver TIG		00XXX h 000XX min 0XX.XX s

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

PRO

Flashing V06N84	Delta V of LM at TIG in Local Vertical Coordinates	X Y Z	XXXX.X ft/s XXXX.X ft/s XXXX.X ft/s

N84 is loaded with the negative of the CSM targeting solution, modified for out-of-plane velocity (YDOT). 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 Coelliptic Sequence Initiation (CSI) maneuvers (P32),
2. Height Adjustment (HAM) maneuver (P31),
3. Final Coelliptic Sequence Initiation (CSI) maneuver (P32),
4. Plane change (PC) maneuver (P36)*,
5. Constant Delta Altitude (CDH) maneuver (P33),
6. Transfer Phase Initiation (TPI) maneuver (P34),
7. Transfer Phase Midcourse (TPM) number one maneuver (P35),
8. Transfer Phase Midcourse (TPM) number two maneuver (P35),
9. Final Rendezvous Attitude maneuver and display (P79).

*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)

P77-CSM TARGET DELTA V PROGRAM

Purpose:

1. To provide a means of notifying the CMC that CSM has changed (or will change) its orbital parameters by the execution of a thrusting maneuver when Average G is not running.
2. To provide to the CMC the Delta V applied to the CSM to enable an updating of the CSM state vector.

Assumptions:

1. The crew has the Delta V applied to the CSM in local vertical coordinates at a specified TIG.
2. R03 should be performed after P77 to update CSM mass.
3. The contents of N81 is the same as the previous value at entrance to P77.

Sequence of Events:

V37E77E

Flashing V06N33	TIG at which Delta V maneuver was executed		00XXX h 000XX min 0XX.XX s

V25E to Load TIG

PRO

Flashing V06N81	Delta V executed in Local Vertical Coordinates	X Y Z	XXXX.X ft/s XXXX.X ft/s XXXX.X ft/s

V25E to load Delta V

PRO

Flashing V37 — Select New Program

P79-FINAL RENDEZVOUS PROGRAM

Purpose:

1. To establish X-axis tracking by P20.
2. To select the rendezvous parameter display (R31) internally to provide range and range rate information prior to the braking phase of rendezvous.

Assumptions:

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

Sequence of Events:

If entered automatically by MINKEY controller, go to MANEUVER.

V37E79E

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

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 between the vehicle X-axis and the LOS to the LM is less than 10 degrees (computed by P20/R61), go to DISPLAY.

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 FDAI angles for automaneuver	OG (R) IG (P) MG (Y)	XXX.XX deg XXX.XX deg XXX.XX deg

PRO

V06N18 — Maneuver in progress

Flashing V50N18 — Maneuver Complete

ENTER Terminates automaneuver, go to DISPLAY.

DISPLAY

Flashing V16N54	Range Range Rate THETA	XXX.XX nmi XXXX.X ft/s XXX.XX deg

PRO

Flashing V37 — Select New Program

R07-MINKEY CONTROLLER ROUTINE

Purpose:

1. To perform automatic sequencing of rendezvous programs.
2. To establish Universal Tracking program (P20) Option 4, with present values for P20 displays.
3. To perform Target Delta V (P76) after each rendezvous maneuver with appropriately computed P76 displays.

Assumptions:

1. The initialization values for the W matrix must be loaded prior to selection of a rendezvous targeting program.
2. This routine is initiated by astronaut selection of a rendezvous targeting program or the Rendezvous Final Phase (P79) program.

Sequence of Events:

The following sequence is presented as a summary of program flow and significant event occurrence for a nominal rendezvous. The MINKEY controller may be activated at any of six reset points: pre-HAM (P31), pre-CS1 (P32), pre-PC (P36), pre-CDH (P33), pre-TPI (P34), or pre-TPM (P35). This sequence is initiated at the HAM maneuver prior to the final CSI maneuver; however, multiple CSI maneuvering may be sequenced by the MINKEY controller.

P31 (HAM Targeting)

1. Start rendezvous navigation (P20) Option 4, with optics tracking assumed; maneuver to track attitude and enable VHF ranging and state vector updating.
2. Perform HAM 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).

P32 (CSI Targeting)

1. Start rendezvous navigation (P20), maneuver to tracking attitude, and enable VHF ranging and state vector updating.
2. Perform CSI targeting computations.
3. Inhibit rendezvous navigation.
4. Select a burn program*.
5. Update LM orbital parameters (P76) for LM thrusting maneuver.
6. Selection of a subsequent targeting program is based on the number of apsides (NN) before CDH. For a multiple CSI rendezvous sequence the number of apsides will be greater than 4.
   a. If NN > 4, select Coelliptic Sequence Initiation targeting (P32).
   b. If NN = 4, select Height Adjust Maneuver targeting (P31).
   c. If NN < 4, select Plane Change targeting (P36).

P36 (PC Targeting)

1. Start rendezvous navigation (P20), maneuver to tracking attitude, and enable VHF ranging and state vector updating.
2. Perform PC targeting computations.
3. Inhibit rendezvous navigation.
4. Plane change realignment option:
   a. If PC Delta V = 0, go to LM Delta V update (P76), 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 5.
      (2) If Y-axis thrusting desired, IMU realignment is bypassed and RCS burn program (P41) is selected.

R07 (continued)

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 ranging and state vector updating.
2. Perform CDH targeting computations.
3. Inhibit rendezvous navigation.
4. Select a burn program*.
5. Update orbital parameters (P76) for LM thrusting maneuver.
6. Select Transfer Phase Initiation targeting (P34)

P34 (TPI Targeting)

1. Start rendezvous navigation (P20), maneuver to tracking attitude, and enable VHF tracking and state vector updating.
2. Perform TPI targeting computations.
3. Inhibit rendezvous navigation.
4. Select a burn program*.
5. Update LM orbital parameter (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 (P35) 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 $\geq$ 7 ft/s, the SPS Burn (P40) program is selected.

CMC ERASABLE PROCEDURES

The following erasable programs and procedures have been developed or are in work by MIT and NASA flight software division to extend the capability of the Colossus software and to provide workarounds in the event hardware malfunctions limit normal use of the G&N system. Erasable memory programs, which involve a software program to be loaded into E-memory, are distinguished from keyboard procedures by an EMP reference number.

Computer Subsystem (CEP 001-009)

CEP 001 Software Restart Initiated by V31. A bailout type software restart (Error Code 31211) can be executed in preference to the hardware restart of V69 by means of this procedure.

Refer to EMP 502.

CEP 002 Saturn Rate Change. Saturn maneuver rates commanded via the RHC during Saturn takeover may be changed as desired using the referenced procedure.

Refer to CSM Launch Checklist L2-33.

CEP 003 CMC Control Mode and Optics Override. S/C attitude and optics mode control inbit or switch failures can be overriden using an erasable mode status register, C31FLWRD, with no loss in mode control capability.

Refer to CSM G&C checklist G1-18.

CEP 004 CSM State Vector Readout and Transfer. Either the CSM or LM state vector may be read out or loaded using the referenced procedure.

Refer to CSM G&C checklist G9-8.

CEP 005 V36 Recovery. Reinitialization of the DAP and reactivation of gyro drift compensation is accomplished following the performance of a Fresh Start.

Refer to CSM G&C checklist G1-20.

CEP 006 General System Checkout. This procedure provides a check on validity of state vector, REFSMMAT, or E-memory dump should a recovery from Standby mode, Fresh Start, or GOJAM be necessary. A procedure is also included to recover from an "ALL8's" display on the DSKY.

Refer to CSM G&C checklist G1-20, 21, and 9-1.

CEP 007 Change ATIGINC. The time delay between rendezvous midcourse targeting and TIG, which allows for preparation of the thrust maneuver, may be changed as desired.

Refer to CSM G&C checklist G4-13.

CEP 008 Intercept Time Display After Final Computation in P34. The time at which the CSM will intercept the LM for the computed TPI maneuver is available in the CMC for display. The intercept time is read out of its E address in octal and then loaded into N34 to facilitate a decimal display.

CEP 009 P37 Range Change Procedure. The value of range (P37RANGE) used in calculating the earth landing coordinates can be changed by first loading R1 of N63 with the desired decimal value, then reading out N63(R1) in octal, and finally loading P37RANGE with the octal value of range.

CEP 010 RMAX/VMAX Loading. Position and velocity vector magnitude changes (N49) for state vector updates can be displayed each measurement by loading sufficiently small values of RMAX or VMAX. These parameters are the largest vector magnitude changes which are incorporated automatically.

Refer to CSM G&C checklist G3-4.

CEP 011 MINIMINKEY. Reduction in the number of key strokes during P23 can be accomplished by inverting REFSMFLG after star-horizon 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.

Refer to EMP 514.

CEP 012 Digital Event Timer. An erasable procedure is proposed to make use of the DSKY as a backup event timer.

Inertial Subsystem (CEP 101-199)

CEP 101 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 IMODES30 and resetting IMODES33 Bit 6.

Refer to PCR 1171.1.

CEP 102 CMC Operation with ISS Turn-On Discrete Failure. To be determined.

Refer to PCR 1172.1

CEP 103 CMC Operation with IMU Operate Discrete Failed-Off. To be determined.

Refer to PCR 1173.1.

CEP 104 Inhibit T4RUPT Coarse Alignment of IMU Because of Runaway ZCDU During Coasting Flight. In the event a ZCDU failure causes an apparent gimbal lock condition, the automatic coarse align moding 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.

Refer to EMP 509.

P40 Termination During AVERAGEG When EMP 509 is Operating. When EMP 509 is running, this procedure is available to facilitate use of P40, 41 thrusting programs without interference with the coarse align inhibiting. The status of AVEGFLAG is maintained while P40 and AVERAGEG are terminated correctly.

Refer to EMP 512.

CEP 105 Rapid IMU Realign. Assuming a good alignment exists on the SCS-GDC, the GDC alignment is transferred to the IMU with a subsequent P52 to fine-align the platform.

Refer to CSM G&C checklist G7-1.

CEP 106 P20 Operation Using GDC REFSMMAT. In the event the IMU is disabled, a REFSMMAT can be computed for the GDC orientation (CEP 117). GDC angles can then be loaded in N20 for P20 computation of desired FDAI angles to align the vehicle pointing axis along the LOS to the LM. Maneuvering is done manually. Fixed attitude marking can then be accomplished by loading N20 with the final GDC angles.

Refer to CSM G&C checklist G3-14.

CEP 107 Enter P51 with IMU Discrete Failed. P51 IMU orientation determinations can be made despite an IMU operate discrete failure.

Refer to PCR 1160.

CEP 108 Entry with a Failed CDU. With proper initialization in P62, a normal entry can be performed with a failed CDU.

Refer to PCR 1169.

CEP 109 Determine IMU Orientation with Failed CDU. Performance of P51 can be enabled with failed ICDU's.

Refer to PCR 1167.1, Colossus memo 329.

CEP 110 Realignment of IMU with Failed CDU's. Performance of P52 can be enabled with failed ICDU's.

Refer to PCR 1166.1, Colossus memo 329.

CEP 111 P40 and P41 with Failed CDU. To be determined.

Refer to Colossus memo 333.

CEP 112 PIPA Bias Measurement and Loading. Onboard measurement of PIPA bias and subsequent loading of bias compensation values is accomplished in this procedure.

Refer to CSM G&C checklist G2-2.

CEP 113 Enable V40 in Apparent Gimbal Lock. For a stable ZCDU in apparent gimbal lock, R3 of N20 is zeroed and V40E is performed. For a runaway ZCDU, EMP 509 is performed and V40E is performed when the gimbal lock light is out.

CEP 114 NBDX Update at Liftoff. Cancelled.

CEP 115 Recovery from Restart During Plane Change Pulse Torquing. Should a restart occur during P.C. pulse torquing, the gyro torquing is suspended and the desired REFSMMAT is not transferred to the present REFSMMAT. This procedure provides for completion of the reorientation and transfer of the REFSMMAT.

Refer to EMP 518.

CEP 116 Changing Landing Site REFSMMAT for Out-of-Plane Burns. This procedure involves altering the landing site latitude by ± 35 degrees and realigning the platform to the recomputed landing site REFSMMAT. This allows maneuvering the vehicle for out-of-plane burns without encountering gimbal lock.
Refer to CSM G&C checklist G7-2.

CEP 117 GDC REFSMMAT Determination. Loading of N20 with GDC angles and proper initiation of P51 logic enables onboard computation of REFSMMAT for GDC orientation.

Refer to CSM G&C checklist G7-13, EMP 503.

CEP 118 CMC Direct Ascent Rendezvous Timeline with IMU Failed. To be determined.

VHF Ranging (CEP 201-299)

CEP 201 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.

Refer to EMP 506.

CEP 202 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.

Refer to CSM G&C checklist G1-20.

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 G3-15, 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 SXTVAR.

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 CDU's 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 than 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 G3-18, EMP 500.

CEP 307 P52 with Frozen Optics. Assuming the CDU's 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 optics coordinates to P20 pointing vector coordinates, gamma, rho and loads them in N78.

Refer to EMP 517.

CEP 311 Alignments with Failed OCDU. 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.