4.6 G&C REFERENCE DATA

This section provides data which generally apply to all G&C procedures in sections 4.7 through 4.16 and 5.1 through 5.3. The data do not include procedures but contains information which may be referenced in various procedures, may contain application of procedures, or may be helpful in applying the procedures.

4.6.1 G&C OPERATING NOTES

G&C operating notes are separated into three categories: G&C operations, SCS operations, and G&N operations. Notes for G&C operations provide data associated with guidance and control functions in general while notes for SCS and G&N operations are more specific to their systems.

4.6.1.1 G&C Operations

1. ULLAGE: For ullage switch setup with or without attitude control, see figure 4.6-1. Normally, the setup should include attitude control.

2. RCS JET, VENT, RADIATOR, AND ANTENNA LOCATIONS: SM and CM RCS jets, vent, and radiator locations are illustrated in figure 4.6-2.

3. SCS LOGIC BUS POWER DISTRIBUTION: SCS logic bus circuit breakers on panel 8 provide MNA and MNB power to four SCS logic buses. Figure 4.6-3 delineates power source and power distribution for SCS controls (pushbuttons, functions, and switches).

   Main bus power to SCS logic buses 1 and 4 is controlled only by the SCS logic bus circuit breakers on panel 8. Power to SCS logic buses 2 and 3 is controlled by SCS logic bus circuit breakers on panel 8 and the LOGIC 2/3 PWR switch on panel 7. Other than SCS TVC, equipment loads can only be removed from a specific logic bus by selecting acceptable control positions not powered by that bus. (See figure 4.6-3.)

Type of Ullage Desired		Required AUTO RCS Switch Positions (Jets Firing*)								RCS Jets* Providing Attitude Hold Capability	
		Pitch				Yaw					
		A3	C3	A4	C4	B3	D3	B4	D4	Pitch	Yaw
2 Jet-Quad A/C Pitch Jets C3 and A4	Without Attitude Control	OFF	MNA or MNB	MNA or MNB	OFF	MNA or MNB	OFF	OFF	MNA or MNB	None	B3 and D4
	With Attitude Control	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	OFF	OFF	MNA or MNB	A3 and C4	B3 and D4
2 Jet - Quad B/D Yaw Jets D3 and B4	Without Attitude Control	MNA or MNB	OFF	OFF	MNA or MNB	OFF	MNA or MNB	MNA or MNB	OFF	A3 and C4	None
	With Attitude Control	MNA or MNB	OFF	OFF	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	A3 and C4	B3 and D4
4 Jet - Quad ABCD Jets A4, B4, C3, D3	Without Attitude Control	OFF	MNA or MNB	MNA or MNB	OFF	OFF	MNA or MNB	MNA or MNB	OFF	None	None
	With Attitude Control	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	MNA or MNB	A3 and C4	B3 and D4

*See figure 4.6-2 for explanation of jet code.

Figure 4.6-1. SCS Ullage Setup

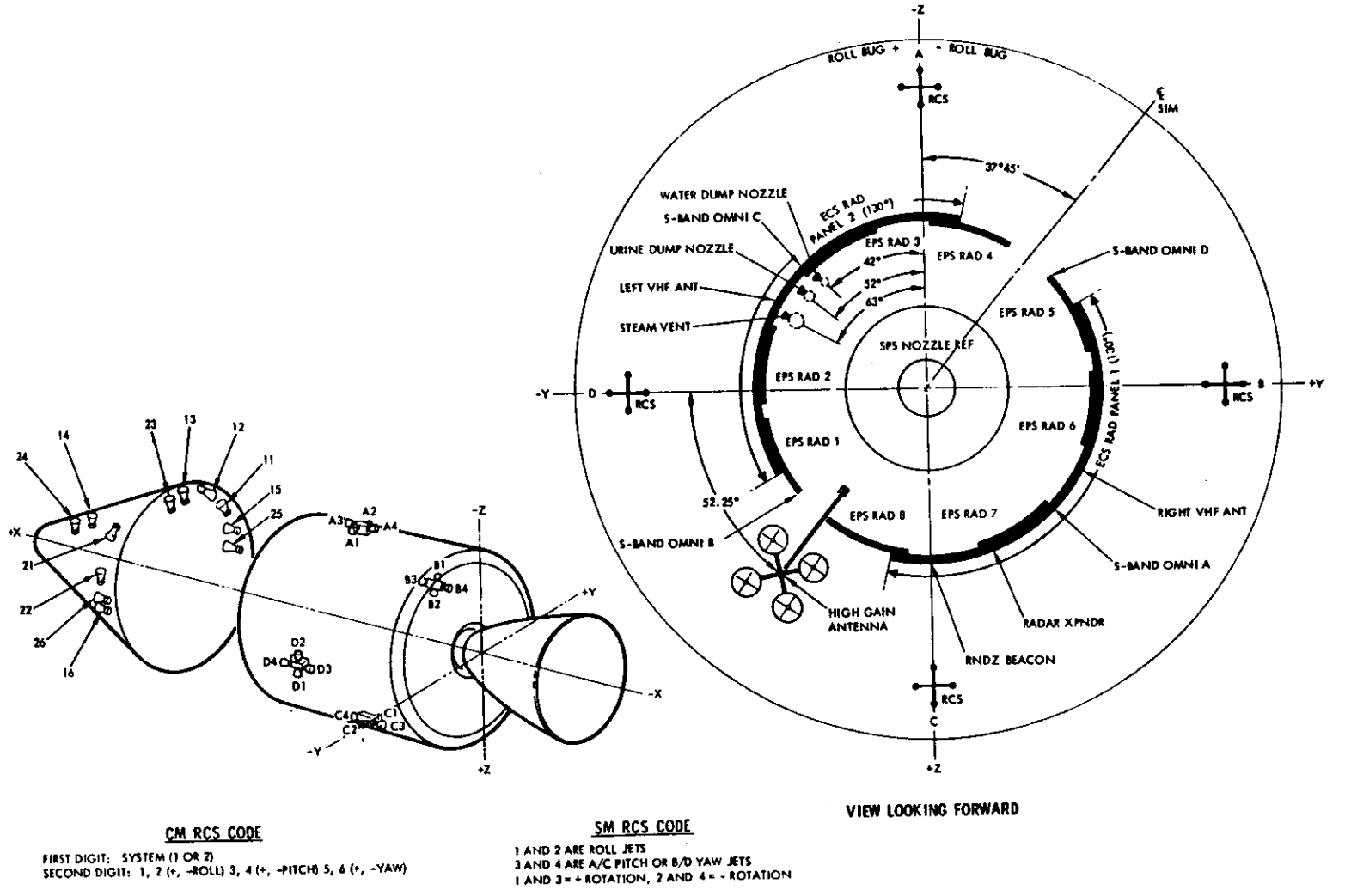

Figure 4.6-2. RCS Jet, Vent, Radiator, and Antenna Locations

CONTROLS		POWER SOURCE				POWER OFF	
TITLE	POSITIONS	BUS 1 (cb direct)	BUS 2 (LOGIC 2/3 PWR sw)	BUS 3 (LOGIC 2/3 PWR sw)	BUS 4 (cb direct)	OPEN CIRCUIT	SWITCHED OFF BY
CMC ATT	IMU	X			X		cb SCS LOGIC 1/2, 1/4, & 3/4
	GDC					X	
FDAI SCALE	5/1					X	
	5/5		X				LOGIC 2/3 PWR
	50/15/50/10				X		cb SCS LOGIC 1/4 & 3/4
FDAI SEL	1/2				X		cb SCS LOGIC 1/4 & 3/4
	1			X			LOGIC 2/3 PWR
	2			X			LOGIC 2/3 PWR
FDAI SOURCE	CMC		X				LOGIC 2/3 PWR
	ATT SET			X			LOGIC 2/3 PWR
	GDC			X			LOGIC 2/3 PWR
ATT SET	IMU		X				LOGIC 2/3 PWR
	GDC				X		cb SCS LOGIC 1/4 & 3/4
MAN ATT (3)	ACCEL CMD	X					cb SCS LOGIC 1/2 & 1/4
	RATE CMD					X	
	MIN IMP	X					cb SCS LOGIC 1/2 & 1/4
LIM CYCLE	on (up)					X	
	OFF	X					cb SCS LOGIC 1/2 & 1/4
ATT DBD	MAX					X	
	MIN	X					cb SCS LOGIC 1/2 & 1/4
RATE	HI	X					cb SCS LOGIC 1/2 & 1/4
	LO					X	

Figure 4.6-3. SCS Logic Bus Power Distribution (Sheet 1 of 2)

CONTROLS		POWER SOURCE				POWER OFF	
TITLE	POSITIONS	BUS 1 (cb direct)	BUS 2 (LOGIC 2/3 PWR sw)	BUS 3 (LOGIC 2/3 PWR sw)	BUS 4 (cb direct)	OPEN CIRCUIT	SWITCHED OFF BY
SC CONT	CMC		X				LOGIC 2/3 PWR
	SCS			X			LOGIC 2/3 PWR
BMAG MODE	RATE 2		(R)	(P & Y)			LOGIC 2/3 PWR
	ATT 1/RATE 2		(R)	(P & Y)			LOGIC 2/3 PWR
	RATE 1	(R,P,Y)					cb SCS LOGIC 1/2 & 1/4
DIR ULL	pb	X					cb SCS LOGIC 1/2 & 1/4
THRUST ON	pb	X					cb SCS LOGIC 1/2 & 1/4
GDC ALIGN	pb				X		cb SCS LOGIC 1/4 & 3/4
SCS TVC (2)	AUTO			X			LOGIC 2/3 PWR
	RATE CMD			X			LOGIC 2/3 PWR
	ACCEL CMD			X			LOGIC 2/3 PWR
ΔV CG	LM/CSM			X			LOGIC 2/3 PWR
	CSM					X	LOGIC 2/3 PWR
EMS ROLL	on (up)				X		cb SCS LOGIC 1/4 & 3/4
	OFF					X	
.05 G sw	on (up)				X		cb SCS LOGIC 1/4 & 3/4
	OFF		X				LOGIC 2/3 PWR
TVC GMBL DR (2)	1					X	
	AUTO	X					cb SCS LOGIC 1/2 & 1/4
	2			X			LOGIC 2/3 PWR
THC	CW sw		X				LOGIC 2/3 PWR

Figure 4.6-3. SCS Logic Bus Power Distribution (Sheet 2 of 2)

CAUTION

SCS logic bus power must not be removed from CMC ATT switch if (1) pitch or yaw rate >5°/second, or (2) GDC yaw Euler angle >80° and <280°. Removing power when either of these conditions exist will result in GDC damage.

4. LIMITED USE CONTROLS: G&C circuit breakers, required for G&C operation, are to be closed during the entire mission except in event of malfunctions. (See figure 4.6-4.) If a malfunction occurs, some circuit breakers may be operated in order to isolate problem areas. Refer to malfunction procedures, section 5.2.

   Figure 4.6-5 defines switches which will remain in same position during major portion of orbital flight time because of functional requirements. Other considerations are to maintain maximum crew safety, increase equipment reliability, and minimize power consumption.

5. ATT SET - IMU FUNCTION: If CMC is on, an overload in IMU resolver circuitry may cause an ICDU oscillation and trigger the ISS warning light (Reference ICD MH01-01325-216). FDAI must be used only as a null meter in this mode of operation. If not, large errors will result because of impedance mismatch. ATT SET switch should be left at GDC when not in use.

   A polarity reversal occurs when ATT SET - IMU option is selected, and roll gimbal angle >±90°. The pitch and yaw attitude error needles become "fly from" indicators rather than "fly to" indicators in this instance.

6. LOGIC 2/3 PWR switch: Required "on" for proper control/display functions (G&N or SCS modes). See figure 4.6-3 for switches whose positions are dependent on this switch being on for proper system operation.

7. MANEUVER >17°: For CMC maneuvers >17° and during SIVB maneuvers, the BMAGs should be caged to prevent them from hitting their stops.

The G&C circuit breakers listed in this chart must be closed throughout the mission except when necessary to correct a malfunction.

Panel 8
- SCS
  - TVC AC1
  - AC (both)
  - ECA/TVC AC2
  - DIR ULL (2)
  - CONTR DIR (4)
  - CONTR AUTO (2)
  - LOGIC (all)
  - SYS (2)
  - A/C ROLL (2)
  - B/D ROLL (2)
  - PITCH (2)
  - YAW (2)
- ORDEAL (2)
- EMS (2)
- RCS
  - SM HTRS (4)
  - PRPLNT (2)
- SPS (12)

Panel 5
- G/N
  - PWR AC (both)
  - IMU (2)
  - IMU HTR (2)
  - CMPTR (2)
  - OPT (2)

Panel 229
- EPS
  - GRP 1 (both)
  - GRP 2 (both)
  - GRP 3 (both)
  - GRP 4 (both)
  - GRP 5 (both)

Figure 4.6-4. Limited Use G&C Circuit Breakers

Switch	Location	Position Major Portion of Mission	When Required	Remarks
CMC ATT	MDC-1	IMU	Normally not touched	Selection of GDC position causes total attitude display to be lost on both balls. Must not be moved to GDC position if (1) pitch or yaw rate is >5 deg/sec, or (2) GDC yaw Euler angle >80° and <280°. GDC damage will result if this is done.
IMU CAGE (guarded)	MDC-1	off (down)	To establish an inertial reference in event of CSS failure or IMU tumbling.	Cage mode zeros the IMU gimbals in a coarse alignment.
EMS ROLL	MDC-1	OFF	Prior to entry	Refer to Entry and Entry Preparation Procedures.
.05 G sw	MDC-1	OFF	At .05 G during entry	Except for entry, on (up) position not desirable (cages BMAGs). Off position powered by LOGIC 2/3 PWR - on (up).
α/Pc IND sw	MDC-1	Pc	Following launch tower jettison	Left in Pc position after tower jettison.
LV IND/GPI sw	MDC-1	GPI	Prior to SPS thrusting	Placed in SII/SIVB position during Prime Crew Prelaunch. Temporarily placed in GPI position for SPS gimbal check at lift off +6 minutes.
LV GUID	MDC-2	IU	If manual inputs to the SIVB control system are required	Nonfunctional after separation from SIVB.
UP TLM	LEB-122	ACPT	Not normally changed	Both UP TLM switches (MDC-2, LEB 122) must be in ACPT position for CMC to accept telem data. MDC-2 switch normally used as control.

Figure 4.6-5. Limited Use Controls

8. ACCEL CMDs: Acceleration commands are available, via RHCs, any time MAN ATT switches are at ACCEL CMD (SC CONT - CMC or SCS). However, ACCEL CMD position inhibits any CMC outputs to RCS jets.

9. EMS MODE switch: EMS MODE switch should be placed to NORM <30 seconds prior to thrusting to minimize buildup of ΔV indicator errors, caused by accelerometer bias. Errors also minimized if set to STBY immediately after thrusting. Otherwise, ΔV ind continues counting.

10. MAN ATT/BMAG MODE switches: Switches may be set by axis, as desired.

11. SPS GMBL MOTORS: Start motors sequentially at ≈1-second intervals to avoid electrical overload. Turn GMBL MOT switches OFF sequentially to avoid power surge. Turning servo 2 off first minimizes switching in the logic.

12. (R02) IMU STATUS check: Procedure prerequisites signify when ISS should be on and a known orientation required. Assuming that prerequisites have been complied with, program alarm for R02 should not occur. If prerequisites are not complied with, program alarm for ISS not on and/or IMU orientation unknown is treated as shown in 4.8.1.16.

13. CMC ATT switch: Normally left at IMU position throughout mission. Selection of GDC position causes total attitude display to be lost on both balls. GDC damage will result if GDC position selected and pitch or yaw rate is >5 deg/sec, or if GDC yaw Euler angle is >80° and <280°.

4.6.1.2 SCS Operations

1. SCS RATE/DEADBAND: During SCS attitude control modes (4.7.1), ATT DBD and RATE switch positions establish rate and deadband response. (See figure 4.6-6.) For FDAI scaling, see figure 4.6-7. Refer to 4.8.2.1 for selection of CMC controlled rate and deadband.

2. SCS JET SEL: Sixteen AUTO RCS switches, consisting of four switch groups titled A/C ROLL, B/D ROLL, PITCH, and YAW with four switches each, enable CM and/or SM jets. Panel nomenclature for AUTO RCS switches summarizes jet characteristics for both SM and CM RCS jets. See figure 4.6-8. Refer to 4.6.1.3, note 1d, and 4.8.2.1 for CMC jet selection.

3. INADVERTENT JET FIRINGS: When powering up SCS, BMAGs should be caged to prevent inadvertent firings of RCS jets.

4. PSEUDO RATE: The pseudo rate function, controlled by LIM CYCLE switch, is used only during SCS attitude hold mode to conserve RCS propellants. However, manual SCS maneuvers with LIM CYCLE switch on cause excessive RCS injector valve cycling and increased propellant consumption. Switch does not function when in computer (CMC) mode. Also refer to note 6.

5. SIG CONDR/DR BIAS PWR switch: Powers RJEC -4 vdc bias power supplies and various SCS signal conditioners for telemetery. To provide increased reliability, switches should not be set on same bus.

6. LIM CYCLE switch: For SCS modes, LIM CYCLE switch should be configured as follows in order to conserve RCS propellant:

   OFF - Manual proportional rate command.
   OFF - Automatic rate damping.
   on (up) - Attitude hold.

7. BMAG PWR switch: When BMAG PWR switches set to OFF, 40-minute warmup may be required (BMAG 1 & 2 TEMP lights out when operating temperature reached) before normal operation of BMAGs. If set from ON to WARMUP, BMAG TEMP lights should remain out.

Control Parameter		SWITCH POSITIONS			
		RATE - LOW*		RATE - HIGH	
		ATT DBD:		ATT DBD:	
		MIN	MAX*	MIN	MAX
Attitude Deadband		±0.2°	±4.2°	±4.0°	±8.0°
Commanded Rates	Pitch & Yaw	±0.7°/sec		±7.0°/sec	
	Roll			±20.0°/sec	
Rate Deadband		±0.2°/sec		±2.0°/sec	

*Recommended position to minimize fuel consumption during attitude hold.

Figure 4.6-6. SCS Rate and Deadband Select Logic

FDAI SCALE SW POS	ATT ERROR			
	FLIGHT PHASE	CMC	SCS	SCS RATES
5/1	Boost & entry	R 20° P&Y 5°	RP&Y 5°	RP&Y 1°/sec
	All other	RP&Y 5°	RP&Y 5°	RP&Y 1°/sec
5/5	Boost & entry	R 20° P&Y 5°	RP&Y 5°	RP&Y 5°/sec
	All other	RP&Y 5°	RP&Y 5°	RP&Y 5°/sec
50/15, 50/10	Boost & entry	R 50°	R 50°	R 50°/sec
		P&Y 15°	P&Y 15°	P&Y 10°/sec
	All other	R 12.5°	R 50°	R 50°/sec
		P&Y 15°	P&Y 15°	P&Y 10°/sec

Figure 4.6-7. FDAI Scaling

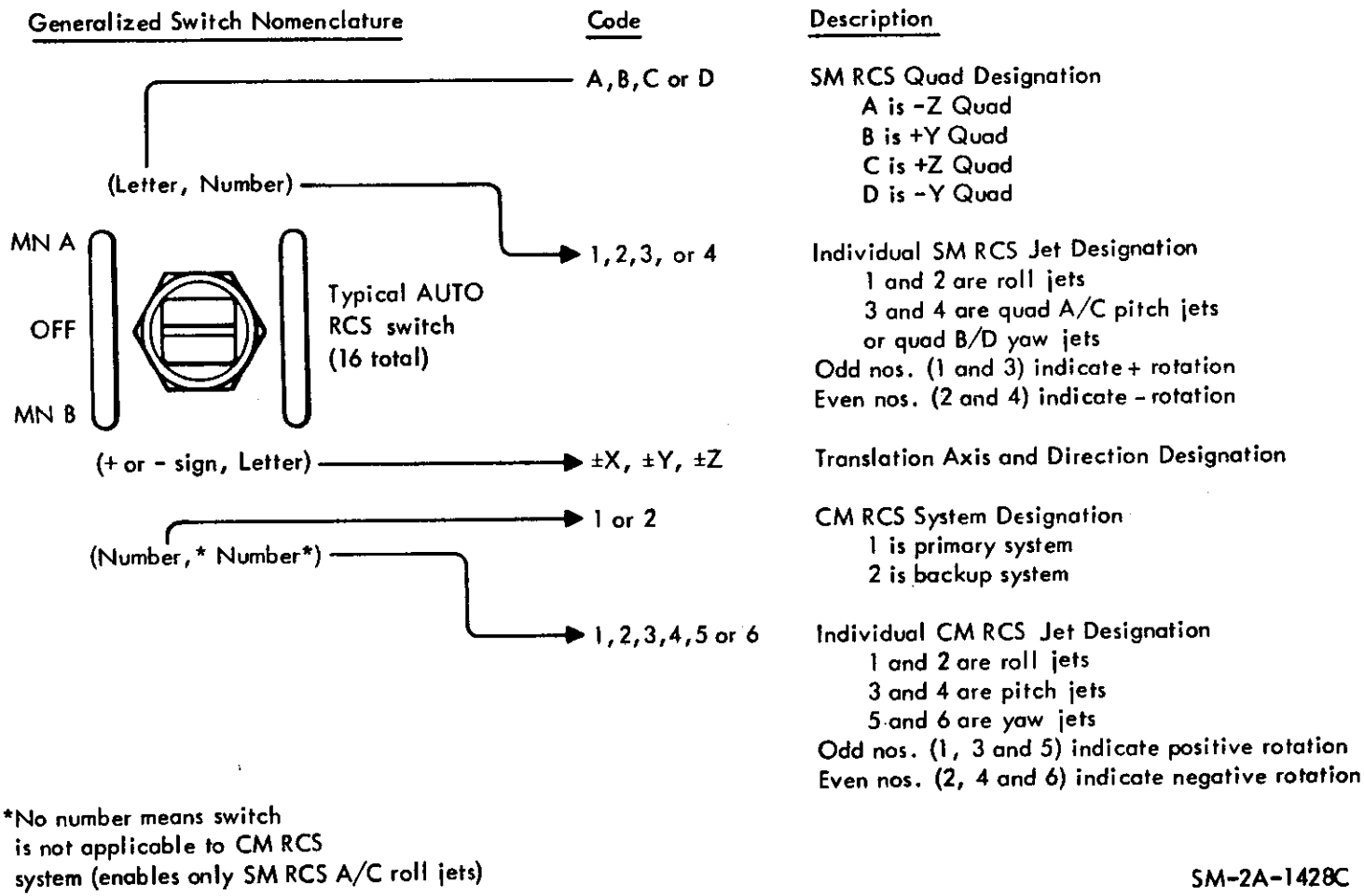

Figure 4.6-8. SCS Jet Select Logic: MDC-8 Nomenclature

4.6.1.3 G&N Operations

1. GENERAL:

a. IMU STBY PWR: If standby power is removed for more than 20 minutes, ISS calibration is no longer valid.

b. CMC CONTROLLED MANEUVERS: During CMC controlled maneuvers, any input from RHC (RHC out of detent) will be interpreted by CMC as a manual override and will cause immediate termination of auto maneuver calculation.

c. VEC POINT ROUTINE: VEC POINT routine (all CMC auto maneuvers except in P23 and R62) may compute large OGA (roll) required when +X must be rotated ≈180°. Sensitivity to such changes gets greater as magnitude increases toward 180°. If desired, a manual maneuver in pitch ≈30° is performed and the solution is then recomputed by keying PRO on FL V50 N18 while not in CMC/AUTO.

d. CMC JET SEL: CMC jet selection is accomplished by performing procedure 4.8.2.1, V48 (R03, DAP Data Load). AUTO RCS switches should correspond to RCS DAP configuration. During SPS thrusting, configuration for AUTO RCS roll enable should agree with RCS DAP load to reduce SPS propellant slosh in event of a failed-on roll jet.

e. IMU GMBL LOCK: If non-G&N controlled attitude maneuvers are made by crew, care must be taken to avoid IMU gimbal lock. IMU gimbal angles may be monitored by observing ICDUs (V16 N20) or by monitoring FDAI ball.

f. CMC PWR: If computer power is switched off, it will be necessary to perform a computer fresh start (V36E) to initialize erasable storage. CMC update program (P27) would have to be done to update the state vector and computer clock time.

g. CLOCK TIME (GET): CMC is capable of maintaining an accurate value of ground elapsed time (GET) for only 23 hours when in standby mode. If CMC is not brought out of standby condition to running condition at least once within 23 hours, CMC value of GET must be updated.

h. IMU ORIENTATION (P51): Time and RCS prplnt may be saved, and subsequent IMU alignment decisions greatly simplified if P51 is performed in such a way as to leave IMU inertially stabilized at an orientation as close as possible to optimum orientation required by future CMC programs.

2. CSS/ISS INTERFACE: Normally the CMC must be ON before the IMU can be operated. However, the IMU may be powered up while the CMC is at STBY. In this condition, the IMU is caged (if powered up) and remains in a coarse align mode. Caging is accomplished internally and does not require any panel switching. However, if the CMC is at STBY, the IMU can be uncaged by placing the IMU CAGE switch to on (up) for ≈5 seconds. V37 should not be called for 15 seconds after NO ATT light goes out. If V37 is called prior to 15 seconds, the PIPA FAIL bit will not be reset and a PIPA FAIL will go undetected.

3. DSKY OPERATIONS: DSKY operations (MDC-2 and LEB-140) require certain restrictions to operation, loading of data, and display of data which are necessary to proper operation. Some general restrictions are listed below. Detailed information relative to DSKY operations is contained in MIT Report E-2129, "Keyboard and Display Program and Operation."

   a. DISPLAY/MONITOR VERBS: For display verbs (01-07), monitor verbs (11-17), and for all load verbs (21-25), the number of components of the verb must not exceed the number of components of the noun being used beginning with noun 04. Noun 01, 02, and 03 may be used with any verb regardless of number of components. If an attempt is made to violate this restriction, the OPR ERR indicator will illuminate when ENTR is pressed to execute the verb/noun action.

   b. OCTAL/DECIMAL MIXING: No mixing of octal and decimal data will be allowed for loads having more than one component. If an attempt is made to violate this restriction, the OPR ERR indicator will illuminate when ENTR is pressed for the last entry.

   c. DECIMAL/OCTAL LOADS: Octal data loads require only significant digits be keyed (e.g., 5, 4, ENTR). Loading decimal data requires each complete entry be made with a sign (+, -), followed by significant digits. Decimal load of less than 5 digits will be

NORMAL/BACKUP

accepted, just as an octal load. Zeros need not be entered ahead of most significant digit. (E.g., for a data load of +925, entry will be made by pressing DSKY keys +, 9, 2, 5, ENTR, and +, ENTR rather than +, 0, 0, 0, 0, 0, ENTR.) When loading decimal data. ENTR sometimes changes last digit of loaded value.

d. MACHINE ADDRESSES: Machine addresses must be loaded in octal.

e. DATA LOAD: If an attempt is made to load a data word which is too large in magnitude for the noun being used, the OPR ERR indicator will illuminate.

All data loads must be verified before pressing ENTR key for last register being loaded. (CLR key has no effect after last ENTR is pressed.) If any of the data is incorrect, register may be cleared by pressing CLR key. Each successive pressing of CLR key will clear preceding register until first register is cleared. (This backing up action will only operate on components called by load verb used.)

f. VERB/NOUN FLASHES: All VERB/NOUN flashes require operator action and the program in progress is halted until appropriate action is taken.

g. PROGRAM SELECTIONS: At times when program selection is not allowable by astronaut action (V37E XXE), R00 will issue a program alarm (01520) and interrupted activity will resume. Attempts to select nonexistent programs will result in an operator error light and return to interrupted program activity and display.

h. PROGRAM TERMINATION: Any program can be terminated at a flashing display via V34E except:

- When P20 is running in background of another program, a V34E on a P20 display (R60 or N49 in R22) will terminate P20 only. Conversely, a V34E on a prethrust program will turn off that program but not P20.
- V34E with an extended verb running will terminate the extended verb only.
- V34E is ignored in P06.

i. V96E: V96E may cause significant loss of W-matrix correlation if keyed in:

- After a V37E XXE from a program using average G and before XX appears in PROG lights.
- During a permanent state vector integration in P20 during mark processing.

To recover, V93E is keyed at some time prior to next navigation marks or VHF range input. In all other cases, use of V96E will cause no ill effects providing next program selected is P00.

j. V82E: After V82E, meaningful information in N50 (splash error) is available only during P11 and P00.

k. EXTENDED VERBS: Extended verbs are not restart-protected. If RESTART light goes on during an extended verb, or if software restart occurs (no RESTART light), the verb should be reselected.

l. VG/ΔV DISPLAYS: VG or ΔV displays in control coordinates, N85 or N83, are based on reading accelerometers every 2 seconds. Displays, however, are asynchronous 1-second monitors. Result is a possible 1/2- to 1-1/2-second delay between application of ΔV and visible result.

m. PRO KEY: A PRO key input is rejected if verb windows show a V21, V22, or V23. V33E must be used for these cases, e.g., a V21 PRO (or V25E PRO) will be rejected; a V25 PRO will not. For the V21, V22, V23 and PRO cases, PRO lights OPR ERR light.

n. KEY REL pb/KEY REL lt: Normal and special cases of KEY REL light and KEY REL push-button use are discussed in the following notes.

<u>KEY REL lt - on</u>

- When internal display comes up while operator has DSKY.
- When internal flashing display is currently on DSKY and keystroke is made except for PRO, ENTR, and ERR RSET.

- Suspended monitor: When operator makes keystroke on top of (his own) monitor verbs (verbs 11-17).

- Remains on after V37 until new program is started. Operator should not use keyboard until KEY REL light is out and new program number is displayed.

o. KEY REL lt - out

- When operator relinquishes DSKY by pressing KEY REL.

- When operator terminates his current sequence normally by:

  Final ENTR of load sequence

  or ENTR, after a response to a flashing display (V34E)

  or ENTR, after an extended verb request (V49E).

p. Special cases of KEY REL

- If operator selects a nonmonitor verb display on top of his own previously selected monitor verb, the KEY REL light will flash. Pressing KEY REL will bring back (unsuspend) the monitor and extinguish light. However, if these sequences are performed on top of an internal display, the KEY REL light will not go out when KEY REL is pressed. One more KEY REL operation (total of two) is required to extinguish KEY REL light, and bring back the internal display.

- If operator selects a verb-noun combination (i.e., V16 monitor) on top of an internal flashing display, the internal display can still be answered with V32E, PRO, or V34E, which wipes everything from the DSKY until the next internal display. However, an operator-selected monitor should, as a rule, never be terminated with V34E. V34E may not be the desired response to the internal flashing display. KEY REL should be used instead. KEY REL need not be used if a data load is interrupted by a priority display.

4. OPTICS MECHANIZATION: Operation of the SCT and SXT requires adherence to certain constraints which are described as follows:

   a. To avoid sun interference, the sun position must be more than 10 degrees from optics shaft-drive axis and more than 15 degrees from star LOS for SXT, and more than 55 degrees from shaft-drive axis for SCT. Within these limits it is possible to use SXT even when sun position is between the SLOS and LLOS. The constraints given, however, do not take into account light scattering which can occur from actual spacecraft configuration.

   b. An adequate portion of the star field must be visible through SCT in order that navigational stars can be recognized. The optics shaft-drive axis thus must be pointed at least 30 degrees above local sunlit earth horizon and at least 20 degrees above local dark earth horizon.

   c. Maximum SXT LOS drive rates are 10 deg/sec for trunnion and 19.5 deg/sec for shaft, with a ±20 percent tolerance. During landmark tracking from a 100-nautical mile earth orbit, in order to be able to maintain optics LOS within the capability of shaft-drive rate, optics LOS to the landmark must be >8.5 degrees from optics shaft-drive-axis ground track at closest point of approach of landmark to shaft-drive-axis ground track. Within this constraint, landmarks on spacecraft ground track can be used by simply rolling CSM so that optic LOS is >8.5 degrees from optics shaft-drive-axis LOS.

   d. TRACKER caution light should be ignored during TVC. Optics CDU fail during TVC, sets TRACKER light which will stay on (even with fail removed) until end of TVC or keying RSET.

   e. During auto optics, computation lag between sampling IMU CDUs and driving optics causes optics to lag behind target. Amount of offset is proportional to CSM angular rate. At usual rate of 4 deg/min, maximum offset would be 0.133°. This will not cause an error during manual tracking and marking.

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

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.6.2	VERB LIST		
	Regular Verbs		
	01 Disp oct compnt 1 (R1)		
	02 Disp oct compnt 2 (R1)		
	03 Disp oct compnt 3 (R1)		
	04 Disp oct compnt 1, 2 (R1, R2)		
	05 Disp oct compnt 1, 2, 3 (R1, R2, R3)		
	06 Disp dec (R1 or R1, R2 or R1, R2, R3)		
	07 Disp DP dec - test only (R1, R2)		
	11 Mon oct compnt 1 (R1)		
	12 Mon oct compnt 2 (R1)		
	13 Mon oct compnt 3 (R1)		
	14 Mon oct compnt 1, 2 (R1, R2)		
	15 Mon oct compnt 1, 2, 3 (R1, R2, R3)		
	16 Mon dec (R1 or R1, R2 or R1, R2, R3)		
	17 Mon DP dec - test only (R1, R2)		
	21 Load compnt 1 (R1)		V33E must be used for accept option if V21, V22, or V23 is in verb window. PRO is not accepted and turns on OPR ERR light.
	22 Load compnt 2 (R2)		
	23 Load compnt 3 (R3)		
	24 Load compnt 1, 2 (R1, R2)		
	25 Load compnt 1, 2, 3 (R1, R2, R3)		
	27 Disp fixed memory		Use in POO only.
	30 Request exec		Use in POO only.
	31 Request waitlist		
	32 Recycle		
	33 Proceed		

STA/T STEP	PROCEDURE	PANEL	REMARKS
	34 Terminate		
	35 Test lights		Use in P00 only.
	36 Req fresh strt		Blanks DSKY displays. May compromise stored state vector requiring a P27 update and IMU orientation determination.
	37 Change prog (major mode)		
	Extended Verbs		
	*40 Zero CDU (with N20)		Ensures sync between ISS CDU counters and CDU counters in CMC. Terminates coarse align and enters fine align.
	41 Coarse align CDU (with N20 & N91)		N20 - Aligns IMU to gimbal angles specified by crew. To coarse align to 0, 0, 0 when GMBL LOCK and coarse align. N91 - To drive optics to shaft and trunnion angles specified by crew (V41 N91 from P00 only).
	42 Pulse torque gyro		Fine align IMU.
	43 Load FDAI att err needles (test only)		P00 only.
	*44 Set surface flag		
	*45 Rset surface flag		
	*46 Activate DAP		
	*47 Set LM state vctr into CSM state vctr		
	48 Strt DAP data load (R03)		Calls up routine 03.
	49 Strt crew defined mnvr (R62)		P00 only.
	50 Please perform		
	51 Please mrk		
	*Callable with another extended verb in use & does not lock out other extended verbs.		

STA/T STEP	PROCEDURE	PANEL	REMARKS
*52	Marked on offset ldg site (P22)		
53	Please mrk alternate LOS		
54	Strt rndz backup sighting mrk (R23)		
55	Increment CMC time (dec)		
*56	Term tracking (P20)		
57	Strt rndz sighting mrk (R21)		
*58	Rset stick flag, set V50 N18 flag		Allows auto maneuvers.
59	Please mrk (opt calib)		
*60	Set att err ref to present att		
*61	Sel mode 1 (disp DAP att err)		Mode 1. FDAI error needles show difference between current and DAP commanded ICDU angles.
*62	Sel mode 2 (disp tot att err)		Mode 2. Display difference between desired final ICDUs (N22) and present ICDUs (N20) resolved into CSM control axes.
*63	Disp tot astronaut att err		Mode 3. Display difference between astronaut total attitude (N17) and present ICDUs (N20) resolved into CSM control axes.
64	Strt S-bd ant routine (R05)		
*65	Strt opt verif of prelaunch align - P03		V65E calls for P03 (during P02 only).
*66	Set CSM state vctr into LM state vctr		
67	Strt W matrix RSS err disp		
*69	Restrt		
70	Strt CMC update - liftoff time (P27)		V70 through V73 are allowed only during P00 or P02.
71	Strt CMC update - block ADR (P27)		
72	Strt CMC update - single ADR (P27)		
73	Strt CMC update - CMC time (P27)		

*Callable with another extended verb in use & does not lock out other extended verbs.

STA/T STEP	PROCEDURE	PANEL	REMARKS
*74	Init erasable dump via downlink		
*75	Backup liftoff		
*76	Set pref att flag		
*77	Rset pref att flag		
*78	Update prelaunch az		
79	Req orbrate/PTC (BBQ mode - R64)		
*80	Enbl LM state vctr update		
*81	Enbl CSM state vctr update		
82	Req orb param disp (R30)		V82E calls R30.
83	Req rndz param disp #1 (R31)		V83E calls R31. V83 and V85 displays will be meaningless at altitudes >432 NM for both earth and moon if exercised during periods of precision vector integration.
85	Req rndz param disp #2 (R34)		V85E calls R34.
*86	Reject rndz backup sighting mrk		
*87	Set VHF range flag		
*88	Rset VHF range flag		
89	Strt rndz fnl att routine (R63)		V89E calls R63 from P00 only.
90	Req rndz out of plane disp (R36)		V90E calls R36.
91	Banksum		P00 only.
*93	Enbl W matrix init		
*94	Enbl cislunar tracking recycle (P23)		
*96	Term integration & go to P00.		
97	SPS thrust fail (R40)		
99	Enbl eng ign		

*Callable with another extended verb in use & does not lock out other extended verbs.

STA/T STEP	PROCEDURE		PANEL	REMARKS
4.6.3	NOUN LIST			All nouns may be loaded via DSKY entry. However, registers containing units of XXBXX cannot be loaded and nouns containing such register data cannot be loaded by V24 or V25.
01	Specify address (fract)		.XXXXX .XXXXX .XXXXX	
02	Specify address (whole)		XXXXX. XXXXX. XXXXX.	
03	Specify address (deg)		XXX.XX XXX.XX XXX.XX	
+05	Angular err/diff		XXX.XX DEG	
+06	Option code ID		OCT	
	Option code		OCT	
+07	Flagword	ECADR	OCT	ECADR ≤30 (octal) will select appropriate channel (except that channel 7 attempts will be ignored).
		BIT ID	OCT	
		ACTION	OCT	
08	Alarm data	ADRES	OCT	
		BBCON	OCT	
		ERCOUNT	OCT	
09	Alarm codes	FIRST	OCT	
		SECOND	OCT	
		LAST	OCT	
10	Chan to be specified		OCT	
11	GETI (CSI)		00XXX. HRS 000XX. MIN 0XX.XX SEC	

+Nouns not manually callable with valid data at any time.

STA/T STEP	PROCEDURE		PANEL	REMARKS
+12	Option code		OCT OCT	Used only with extended verbs.
13	GETI (CDH)		00XXX. HRS 000XX. MIN 0XX.XX SEC	
15	Increment address		OCT	Used with N01, N02, and N03.
+16	Time of event		00XXX. HRS 000XX. MIN 0XX.XX SEC	Used by extended verb only.
17	Astronaut tot att	R P Y	XXX.XX DEG XXX.XX DEG XXX.XX DEG	Used in Mode 3 needles (V63).
18	Auto mnvr	R P Y	XXX.XX DEG XXX.XX DEG XXX.XX DEG	
20	ICDU angles	OG-R IG-P MG-Y	XXX.XX DEG XXX.XX DEG XXX.XX DEG	
21	PIPAS	X Y Z	XXXXX. Pulses XXXXX. Pulses XXXXX. Pulses	
22	New ICDU angles	OG-R IG-P MG-Y	XXX.XX DEG XXX.XX DEG XXX.XX DEG	
+24	Δ time for CMC clock		00XXX. HRS 000XX. MIN 0XX.XX SEC	V25 N24 display initiated by V55E.
+25	Checklist		XXXXX.	Used with V50.
+26	Prio/delay		OCT	Used with V30, V31.
	ADRES		OCT	
	BBCON		OCT	

+Nouns not manually callable with valid data at any time.

STA/T STEP	PROCEDURE	PANEL	REMARKS
27	Self-test on/off sw	XXXXX.	
+29	X SM launch az	XXX.XX DEG	
+30	Trgt code (gyro compassing verif)	XXXXX. XXXXX. XXXXX.	
32	TF perigee	00XXX. HRS 000XX. MIN 0XX.XX SEC	Time from perigee/perilune.
33	GETI	00XXX. HRS 000XX. MIN 0XX.XX SEC	GETI - ground elapsed time of ignition.
+34	Time of evnt	00XXX. HRS 000XX. MIN 0XX.XX SEC	
35	Time from evnt	00XXX. HRS 000XX. MIN 0XX.XX SEC	
36	Time of CMC clock	00XXX. HRS 000XX. MIN 0XX.XX SEC	
37	GETI (TPI)	00XXX. HRS 000XX. MIN 0XX.XX SEC	
38	Time of state vctr	00XXX. HRS 000XX. MIN 0XX.XX SEC	
39	ΔT for trnfr	00XXX. HRS 000XX. MIN 0XX.XX SEC	
40	TF GETI/TFC VG ΔV (accum)	XXBXX MIN-SEC XXXX.X FPS XXXX.X FPS	This is a no load noun (OPR ERR).

+Nouns not manually callable with valid data at any time.

STA/T STEP	PROCEDURE		PANEL	REMARKS
+41	Trgt	Az	XXX.XX DEG	N41 - 2 component noun.
		Elev	XX.XXX DEG	
		ID	0000X.	
42	Ha		XXXX.X NM	Apogee/apolune altitude.
	Hp		XXXX.X NM	Perigee/perilune altitude.
	ΔV (req)		XXXX.X FPS	
43	Lat (+N)		XXX.XX DEG	
	Long (+E)		XXX.XX DEG	
	Alt		XXXX.X NM	
44	Ha		XXXX.X NM	Apogee altitude. This is a no load noun (OPR ERR).
	Hp		XXXX.X NM	Perigee altitude.
	TFF		XXBXX MIN-SEC	Time of freefall to 49.4 NM (300,000 ft) above launch pad radius for earth orbit, or for lunar orbit, 5.8 NM (35,000 ft) above lunar radius at most recently defined lunar landing site.
45	Mrks (VHF/opt)		XXBXX MKS	This is a no load noun (OPR ERR).
	TF GETI (next burn)		XXBXX MIN-SEC	
	MGA		XXX.XX DEG	
46	DAP config		OCT	Loads configuration for use by DAPS.
			OCT	
47	CSM wt		XXXXX. LB	Loads vehicle weights for use by DAPs.
	LM wt		XXXXX. LB	
48	Pitch trim		XXX.XX DEG	Loads pitch and yaw trim angles.
	Yaw trim		XXX.XX DEG	
49	ΔR		XXXX.X NM	
	ΔV		XXXX.X FPS	
	Code		0000X.	

+Nouns not manually callable with valid data at any time.

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
50	Splash err	XXXX.X NM	Negative for undershoot, positive for overshoot. This is a no load noun (OPR ERR).
	Hp	XXXX.X NM	
	TFF	XXBXX MIN-SEC	Time of freefall.
51	Rho	XXX.XX DEG	
	Gamma	XXX.XX DEG	
52	CENTANG (active veh)	XXX.XX DEG	Central angle of active vehicle.
53	Range	XXX.XX NM	
	Range rate	XXXX.X FPS	
	Phi (lcl horiz/SLOS)	XXX.XX DEG	0 to 180° = SLOS above plane.
54	Range	XXX.XX NM	Range to LM.
	Range rate	XXXX.X FPS	
	Theta (lcl horiz/ CSM +X)	XXX.XX DEG	0 to 180° = +X above plane.
55	NN	0000X.	Display definition depends on using program/routine.
	E	XXX.XX DEG	Elevation.
	CENTANG (passive veh)	XXX.XX DEG	Central angle of passive vehicle.
56	Reentry angle	XXX.XX DEG	
	ΔV	XXXXX. FPS	
58	Hp (post TPI)	XXXX.X NM	Perigee alt (post TPI).
	ΔV (TPI)	XXXX.X FPS	
	ΔV (TPF)	XXXX.X FPS	
59	ΔV LOS 1	XXXX.X FPS	
	ΔV LOS 2	XXXX.X FPS	
	ΔV LOS 3	XXXX.X FPS	
60	G max	XXX.XX G	
	V pred	XXXXX. FPS	
	Gamma EI [lcl horiz/VI (+up)]	XXX.XX DEG	
61	Impact Lat (+N)	XXX.XX DEG	
	Impact Long (+E)	XXX.XX DEG	
	Hds up/down (+Hds up)	+/-00001.	

STA/T STEP	PROCEDURE	PANEL	REMARKS
62	VI	XXXXX. FPS	Inertial velocity.
	H dot	XXXXX. FPS	Altitude rate.
	H pad	XXXX.X NM	Altitude above pad radius (earth orbit) or landing site radius (lunar orbit).
63	RTOGO (.05 G to splash)	XXXX.X NM	One shot display, should always be positive. .05 G represents pad loaded altitude. This is a no load noun (OPR ERR).
	VIO (at .05 G)	XXXXX. FPS	Predicted inertial velocity.
	TFE (time from .05 G)	XXBXX MIN-SEC	
64	Drag accel	XXX.XX G	
	VI	XXXXX. FPS	Inertial velocity.
	Range to splash	XXXX.X NM	Negative and counting down when approaching target; positive and counting up when leaving target.
65	Sampled CMC time	00XXX. HRS 000XX. MIN 0XX.XX SEC	Fetched in interrupt.
66	Beta	XXX.XX DEG	Commanded bank angle.
	CRSRNG ERR	XXXX.X NM	Positive to right of plane (LATANG +South); negative to left of plane (-North).
	DNRNG ERR	XXXX.X NM	Negative for undershoot (PREDANGLE -θ); positive for overshoot.
67	Range to splash	XXXX.X NM	Negative counting down for approaching target; positive counting up for leaving target.
	Lat [Present pos (+N)]	XXX.XX DEG	
	Long [Present pos (+E)]	XXX.XX DEG	

STA/T STEP	PROCEDURE	PANEL	REMARKS
68	Beta	XXX.XX DEG	Commanded bank angle.
	VI	XXXXX. FPS	Inertial velocity.
	H dot	XXXXX. FPS	Altitude rate.
69	Beta	XXX.XX DEG	Beta - commanded bank angle.
	DL	XXX.XX G	DL - drag acceleration at end of up-control.
	VL	XXXXX. FPS	VL - velocity at end of up-control.
70	Star code (before mrk)	OCT	
	Lmk data	OCT	
	Horiz data	OCT	
71	Star code (after mrk)	OCT	
	Lmk data	OCT	
	Horiz data	OCT	
73	Alt/10	XXXXX. NM	On call in P21.
	VI	XXXXX. FPS	
	Gamma	XXX.XX DEG	
74	Beta	XXX.XX DEG	
	VI	XXXXX. FPS	
	Drag accel	XXX.XX G	
75	Δ alt (CDH)	XXXX.X NM	
	ΔT (CDH -CSI or TPI -CDH)	XXBXX MIN-SEC	
	ΔT (TPI -CDH or TPI -NOM TPI)	XXBXX MIN-SEC	
79	Rate	X.XXXX DEG/SEC	Used with V79.
	DBD	XXX.XX DEG	
	Axis option (X or Y)	0000X.	0 = X (PTC), non-zero = Y (orbrate).
80	Time to ign (cutoff)	XXBXX MIN-SEC	
	VG	XXXXX. FPS	
	ΔV (accum)	XXXXX. FPS	
81	ΔVX (lcl vert)	XXXX.X FPS	(ΔV components).
	ΔVY (lcl vert)	XXXX.X FPS	
	ΔVZ (lcl vert)	XXXX.X FPS	

STA/T STEP	PROCEDURE		PANEL	REMARKS
82	ΔVX (lcl vert)		XXXX.X FPS	
	ΔVY (lcl vert)		XXXX.X FPS	
	ΔVZ (lcl vert)		XXXX.X FPS	
83	ΔVX (cont)		XXXX.X FPS	(ΔV components) control = CSM control axes.
	ΔVY (cont)		XXXX.X FPS	
	ΔVZ (cont)		XXXX.X FPS	
84	ΔVX (other veh)		XXXX.X FPS	(ΔV components).
	ΔVY (other veh)		XXXX.X FPS	
	ΔVZ (other veh)		XXXX.X FPS	
85	VGX (cont)		XXXX.X FPS	(VG vector components) control = CSM control axes.
	VGY (cont)		XXXX.X FPS	
	VGZ (cont)		XXXX.X FPS	
86	ΔVX (lcl vert)		XXXXX. FPS	
	ΔVY (lcl vert)		XXXXX. FPS	
	ΔVZ (lcl vert)		XXXXX. FPS	
87	Mrk data	Shft	XXX.XX DEG	
		Trun	XX.XXX DEG	
88	Planet	X	.XXXXX	Unit position vector.
		Y	.XXXXX	
		Z	.XXXXX	
89	Lmk	Lat (+N)	XX.XXX DEG	
		Long/2 (+E)	XX.XXX DEG	
		Alt	XXX.XX NM	
90	Rndz out of plane param	Y	XXX.XX NM	
		Y Dot	XXXX.X FPS	
		Psi	XXX.XX DEG	
91	Present OCDU angles	Shft	XXX.XX DEG	
		Trun	XX.XXX DEG	
92	New OCDU angles	Shft	XXX.XX DEG	
		Trun	XX.XXX DEG	
93	Δ gyro angles	X Gyro	XX.XXX DEG	
		Y Gyro	XX.XXX DEG	
		Z Gyro	XX.XXX DEG	

NORMAL/BACKUP

STA/T STEP	PROCEDURE		PANEL	REMARKS
94	Alternate LOS	Shft	XXX.XX DEG	
		Trun	XX.XXX DEG	
95	Pref att (FDAI angles)	Roll	XXX.XX DEG	Preferred tracking attitude ICDU angles.
		Pitch	XXX.XX DEG	
		Yaw	XXX.XX DEG	
96	+X axis att (FDAI angles)	Roll	XXX.XX DEG	
		Pitch	XXX.XX DEG	
		Yaw	XXX.XX DEG	
+97	Sys test inputs		XXXXX.	
			XXXXX.	
			XXXXX.	
+98	Sys test results and inputs		XXXXX.	
			.XXXXX	
			XXXXX.	
99	POS ERR		XXXXX. FT	RSS value of position error.
	VEL ERR		XXXX.X FPS	RSS value of velocity error.
	Option code		0000X.	Option code: 00001 - Rendezvous 00002 - Orbital 00003 - Cislunar

+Nouns not manually callable with valid data at any time.

STA/T STEP	PROCEDURE	PANEL	REMARKS

4.6.4 STAR LIST

NO.	STAR NAME (Numerical)	STAR NAME (Alphabetical)	NO.
1	Alpheratz	Acamar	6
2	Diphda	Achernar	4
3	Navi	Acrux	25
4	Achernar	Aldebaran	11
5	Polaris	Alkaid	27
6	Acamar	Alphard	21
7	Menkar	Alphecca	32
10	Mirfak	Alpheratz	1
11	Aldebaran	Altair	40
12	Rigel	Antares	33
13	Capella	Arcturus	31
14	Canopus	Atria	34
15	Sirius	Canopus	14
16	Procyon	Capella	13
17	Regor	Dabih	41
20	Dnoces	Deneb	43
21	Alphard	Denebola	23
22	Regulus	Diphda	2
23	Denebola	Dnoces	20
24	Gienah	Enif	44
25	Acrux	Fomalhaut	45
26	Spica	Gienah	24
27	Alkaid	Menkar	7

Vis Mag, Right Ascension and Declination data are relative to the numerical list.

Vis Mag	Right Ascension (hr)	(min)	(sec)	Declination (deg)	(min)	(sec)
2.1	0	06	49.9	+28	55	29
2.2	0	42	05.0	-18	09	04
Var	0	54	53.0	+60	33	17
0.6	1	36	35.9	-57	23	20
2.1	2	03	18.9	+89	07	34
3.4	2	57	07.4	-40	25	27
2.8	3	00	42.5	+03	58	23
1.9	3	22	10.3	+49	45	21
1.1	4	34	11.8	+16	27	01
0.3	5	13	05.7	-08	14	06
0.2	5	14	28.2	+45	58	10
-0.9	6	23	17.1	-52	40	44
-1.6	6	43	49.6	-16	40	25
0.5	7	37	43.9	+05	18	11
1.9	8	08	36.4	-47	14	51
3.1	8	57	09.7	+48	09	38
2.2	9	26	06.8	-08	31	40
1.3	10	06	46.5	+12	06	52
2.2	11	47	31.8	+14	44	23
2.8	12	14	15.6	-17	22	32
1.0	12	24	54.9	-62	55	59
1.2	13	23	36.6	-11	00	19
1.9	13	46	21.6	+49	27	45

STA/T STEP	PROCEDURE		PANEL	REMARKS						
					Right Ascension			Declination		
NO.	STAR NAME (Numerical)	STAR NAME (Alphabetical)	NO.	Vis Mag	(hr)	(min)	(sec)	(deg)	(min)	(sec)
30	Menkent	Menkent	30	2.3	14	04	54.6	-36	13	23
31	Arcturus	Mirfak	10	0.2	14	14	17.5	+19	20	16
32	Alphecca	Navi	3	2.3	15	33	25.0	+26	48	53
33	Antares	Nunki	37	1.2	16	27	33.9	-26	22	01
34	Atria	Peacock	42	1.9	16	45	28.3	-68	58	31
35	Rasalhague	Polaris	5	2.1	17	33	32.4	+12	34	50
36	Vega	Procyon	16	0.1	18	35	55.3	+38	45	17
37	Nunki	Rasalhague	35	2.1	18	53	24.3	-26	20	08
40	Altair	Regor	17	0.9	19	49	19.1	+08	47	16
41	Dabih	Regulus	22	3.2	20	19	19.6	-14	49	38
42	Peacock	Rigel	12	2.1	20	23	17.0	-56	50	58
43	Deneb	Sirius	15	1.3	20	40	24.4	+45	10	21
44	Enif	Spica	26	2.5	21	42	42.7	+09	44	12
45	Fomalhaut	Vega	36	1.3	22	55	59.7	-29	46	54

STAR LIST

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.6.5 CHECKLIST REFERENCE CODES (V50 N25)			
R1 Code	ACTION	FUNCTION	
00013	Perform	Coarse align or pulse torque	
00014	Perform	Fine align option	
00015	Perform	Trgt acq	Target (celestial body) acquisition - Used in conjunction with N70, N71 and the following celestial body codes: 00 - Planet (any planet except Earth) 01 to 45 - Star 46 - Sun 47 - Earth 50 - Moon
00016	Key in	Term mrk seq	
00041	Sw	CM/SM sep to up	
00062	Sw	CMC pwr down	
00202	Perform	G&N auto mnvr	
00204	Perform	Enbl gmbl trim option	

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS

4.6.6 OPTION CODES (V04 N06 or V04 N12)

R1 Code	Purpose	Input for R2
00001	Specify IMU orientation	1 = PREF 2 = NOM 3 = REFSMMAT 4 = Ldg site
00002	Specify veh	1 = This veh 2 = Other veh
00003	Specify tracking att	1 = PREF 2 = +X axis
00007	Specify propul sys	1 = SPS 2 = RCS

Specified option codes will be flashed in R1 in conjunction with V04 N06 or V04 N12. Requests desired option be loaded into R2.

STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.6.7 ALARM CODES (V05 N09)		Alarms for V05 N09 (ERR RSET zeros R1 and R2; leaves R3 alone) R1 - first alarm to occur R2 - second alarm to occur R3 - last alarm to occur (There is no indication as to whether 3, or more than 3, alarms have occurred)
	Codes starting with 2 signifies POODOO routine: generates software restart (if ave G running, same as BAILOUT; if not, goes to ROO). Will not turn on RESTART lt		The following list shows general numbering logic for alarm codes excluding interfaces and exceptions: 00100-00200 Optics subsystem 00200-00300 IMU subsystem 00400-00600 Rendezvous 01100-01200 Computer hardware malfunctions 01200-01300 List overflows (all aborts) 01300-01400 Interpreter errors 01400-01500 Display alarms 01500-01600 Keyboard and display programs 01600-01700 System test alarms 01700-01800 DAP display alarms
	Codes starting with 3 signifies BAILOUT routine: generates software restart (returns to interrupted program). Does not turn on RESTART lt		
	00110 Mrk reject has been entered but ignored (continue)		Either no marks have been received or there have been no marks since last mark reject.
	00112 Mrk reject with no mrks being acptd (continue)		
	00113 No inbits (chan 16) (continue)		If alarm recurs, use MDC DSKY.
	00114 More mrks made than desired (continue)		
	00115 V41 N91 keyed with OPT MODE not in CMC		Set OPT MODE - CMC and OPT ZERO - OFF. OPR ERR also lights.
	00116 Opt sw altered before 15 sec zero time elapsed		Set OPT ZERO - ZERO (≈15 sec to zero).

STA/T STEP	PROCEDURE	PANEL	REMARKS
00117	V41 N91 keyed but CMC has reserved OCDU		V41 N91 not yet available. May occur from start of drive test until end of burn.
00120	Opt torque has been req but opt have not been zeroed since last FRESH START or RESTART		Set OPT ZERO - OFF then ZERO (≈15 sec to zero).
00121	SC att rates of ≥ two-thirds deg per sec will result in auto reject of sighting mrks		Repeat mark.
00122	Marking not called for (continue)		
00205	PIPA saturated		Use SCS control. Refer to G&N malfunction procedures, symptom 12. While thrusting navigation (average G) is operating, a PIPA output in excess of 6399 pulses in a 2-second period has been detected.
00206	IMU zero routine has been entered with both GMBL LOCK lt and NO ATT lt on		Coarse align to 0, 0, 0. Reselect V40 N20E. IMU mode switching.
00207	ISS turn-on req not present for 90 sec		Redo IMU turn on. Refer to G&N malfunction procedures, symptom 12.
00210	ISS not on		Redo IMU turn on. If alarm recurs, perform fresh start (V36E). Consult MSFN. Refer to malfunction procedures, symptom 12. Used by IMU zero routine, R02, P51, and P53.
00211	Coarse align err		If P51, 53/P52, 54 in progress, record gyro torquing angles and perform fine align check in P52, 54. Otherwise, refer to V41 N20. Refer to G&N malfunction procedures, symptom 12. Following coarse align, an ICDU is found not to be within 2° of its desired value.

STA/T STEP	PROCEDURE	PANEL	REMARKS
00212	PIPA fail, but PIPA not being used		PIPA BIAS check. Refer to G&N malfunction procedures, symptom 6, step 7. A PIPA fail signal has been received by CMC but PIPAs are not being used (average G not on); or CMC has just finished with PIPAs and finds a PIPA fail signal. For latter case, ISS warning light is extinguished.
00213	IMU not operating with turn-on req		Refer to 00210. CMC has detected an ISS turn-on request but finds ISS operate not present.
00214	Prog using IMU when turned off		Refer to 00210 or exit program. IMU not in use (IMUSE flag reset). IMU in use (IMUSE flag set).
00217	IMU coarse align or pulse torque difficulty has occurred		Reinitiate current program. If alarm recurs, terminate use of ISS. Refer to G&N malfunction procedures, symptom 12. This alarm is issued in alignment program, P5X, if coarse align or gyro torquing attempted during IMU turn-on, while a cage command is present or while IMU zeroing is taking place. It is also issued if coarse align failure has occurred (code 211) or if CMC detects ISS warning light on at end of a "successful" coarse alignment or gyro torquing process.
00220	IMU orient unknown		Align or if aligned, set REFSMMAT flag.
00401	Desired middle gmbl angle excessive		Call N22 - maneuver if MGA <85° or realign IMU. Alarm will be generated if MGA >60° is calculated during: a. Realignment in P52/54 b. Entry attitude in P62, P66 display, and P64 (if velocity is <27K FPS at .05 G point).

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
00404	Trgt out of view (90 deg test)		P52, P22 and P23. A trunnion angle >90° required to acquire star or landmark. This is a priority alarm and will be displayed by CMC with a flashing V05 N09.
00405	Acpt star pair not avail		In P52 and P54, CMC searches for pair of nav stars which are not <30° and not >76° apart. In addition, neither star may be occulted by earth, sun or moon, and each star must be within 38° of optics shaft axis. If no such pair can be found, alarm is displayed automatically by computer with a flashing V05 N09.
00406	Rndz nav not oper		Select P20 or continue. V54 or V57 has been entered but rendezvous tracking is not operating. CMC ignores request for marks and reinstates interrupted display, if any.
00421	W-matrix overflow		Notify MSFN but continue. W-matrix automatically reinitialized at next mark.
20430	Orb integration		Notify MSFN. Probable state vector uplink required. This may happen if CMC attempts to integrate a state vector that intersects earth or moon. A state vector update may be required.
00600	Imaginary roots on 1st iteration		P32, P72.
00601	Post CSI Hp <5.8 NM (85 NM for E.O.)		P32, P72.
00602	Post CDH Hp <5.8 NM (85 NM for E.O.)		P32, P72.
00603	CDH -CSI <10 min		P32, P72.
00604	TPI -CDH <10 min		P32, P72.
00605	No. of iterations exceeds loop max		P32, P72, P37.

ALARM CODES (V05 N09)

STA/T STEP	PROCEDURE	PANEL	REMARKS
00606	ΔV exceeds max		P32, P72.
20607	No solution from time θ or time radius		Reselect program. Vehicle will be in a hyperbolic orbit, or entry angle too steep.
20610	Lambda < unity		Reselect P37 and decrease TIG. Selected GETI yields a radius < entry interface radius.
00611	No TIG for given ELEV angle		P33, P34, P73, P74.
00612	State vctr in wrong sphere of influence		P37.
00613	Re-entry angle out of limits		P37.
00777	ISS warning caused by PIPA fail		Refer to G&N malfunction procedures, symptom 6.
01102	CMC self test err		Self check.
21103	Unused CCS branch executed		Copy N08, notify MSFN. Initiate V36 recovery. CMC has branched to an illogical point in its instruction sequence.
31104	Delay routine busy		Reselect extended verb or continue with program. Notify MSFN. An internal routine (DELAYJOB) used by CMC to cause variable time delays, has received requests from more than 4 jobs.
01105	Downlink too fast		Rset. If alarm recurs, DOWNLINK FAILURE. Refer to G&N malfunction procedures, symptom 12.
01106	Uplink too fast		Rset. If alarm recurs, UPLINK FAILURE. Refer to G&N malfunction procedures, symptom 12.

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
01107	Phase table failure - assume erasable memory is destroyed		Perform: 1. V74 CMC DOWNLINK 2. P27 as necessary 3. V48 as necessary (V46) 4. Re-establish REFSMMAT via P51 as necessary. If FRESH START recurs, CMC FAILURE. Refer to malfunction procedures, symptom SSR-3. During CMC restart, a phase table disagreement was found. CMC will perform an automatic fresh start if this condition exists.
31201	Exec overflow - no VAC area		Reselect extended verb and/or continue program.
31202	Exec overflow - no core sets		Refer to 31201.
31203	Waitlist overflow - too many tasks		Refer to 31201.
21204	Neg or zero waitlist call		If average G on, continue. Otherwise reselect program.
21206	Second job attempts to go to sleep via keyboard and disp prog		Refer to 21204.
31207	No VAC area for marks		Rset. Reselect program. If alarm recurs, consult MSFN.
21210	Second attempt is made to stall		Reselect program. Do not attempt use of device while CMC is using it. While performing certain IMU mode switching functions or while performing automatic attitude maneuvers CMC begins a function or maneuver and then "stalls" until appropriate job has been completed. If a second attempt is made to stall for the same reason (i.e., IMU mode switch or attitude maneuver), this alarm is generated.

STA/T STEP	PROCEDURE	PANEL	REMARKS
31211	Illegal interrupt of extended verb		Reselect extended verb after optics marking completed. If an internal request for marks (SXTMARK or R57) made, CMC tests to see if mark system already busy or if an extended verb active. If either condition is discovered, alarm is generated.
01301	Arcsin or arccos input >1		Copy N08, notify MSFN, continue. Refer to 21103.
21302	SQRT called with neg argument		
01407	VG incr		P40. Refer to G&N malfunction procedures, symptom 12. CMC has determined that last measured value of ΔV was in such a direction as to cause VG to increase rather than decrease. As long as this condition exists, value of time to go to cutoff is not recalculated (although R1 of N40 will continue to count down) and an automatic engine-off command will not be sent by CMC.
01426	IMU unsatisfactory		Realign or use SCS. Neither +Y stable member axis nor -Y stable member axis within 30° of $\underline{V} \times \underline{R}$ where $\underline{V}$ and $\underline{R}$ are present vehicle velocity and position vectors respectively. The test for this condition performed at beginning of P61 and P62.
01427	IMU reversed		Note FDAI operation is inverted. The -Y stable member axis is within 30° of $\underline{V} \times \underline{R}$ (cf. code 1426).
21501	Keyboard and disp alarm during internal use (NVSUB).		Refer to 21103.
21502	Illegal flashing disp		Refer to 21103.

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
01520	V37 req not permitted at this time		Wait until COMP ACTY light not on continuously, reselect V37 or if P62/P67, select P00 and then desired program. Alarm will be generated if a V37 request made with IMU as follows: a. In its 90-second turn-on period b. Being caged c. Being zeroed. It will also be generated if V37 request is made for a program other than P00 after entry DAP has been started in P62, during P76 and P00 integration, in P06 and during optics zeroing.
21521	P01 or P07 illegally sel		Refer to 21204.
01600	Overflow in drift test		This is ground test alarm only.
01601	Bad IMU torque abort		Refer to 01600. Generated in P01, P02, or P07.
01602	Bad opt during verif		Refer to 01600. This alarm cannot be operated by the CMC.
01703	Insufficient time for integration		P40, P41. Will occur between TIG -42.5 and TIG -35 seconds.
03777	ISS warning caused by ICDU fail		Refer to G&N malfunction procedures, symptom 6.
04777	ISS warning caused by ICDU and PIPA fail		Refer to G&N malfunction procedures, symptom 6.
07777	ISS warning caused by IMU fail		Refer to G&N malfunction procedures, symptom 6.
10777	ISS warning caused by IMU and PIPA fail		Refer to G&N malfunction procedures, symptom 6.
13777	ISS warning caused by IMU and ICDU fail		Refer to G&N malfunction procedures, symptom 6.
14777	ISS warning caused by IMU, ICDU, and PIPA fail		Refer to G&N malfunction procedures, symptom 6.

ALARM CODES (V05 N09)

STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.6.8 CMC PROGRAM - ROUTINE INDEX		
	4.6.8.1 Programs		

Phase	Program No.	Program Title	Contains Crew Interface Routines
Pre-Launch & Service	00	CMC idling	None
	01	Prelaunch or service init	None
	02	Prelaunch or service gyro compassing	None
	03	Prelaunch or service opt verif of gyro compassing	None
	06	CMC pwr down	R00
	07	Sys test	
Boost	11	Earth orb insertion mon	None
	15	CMC TB6 init	R00
Coast	20	Rndz nav	R02,R61,R52, R00,R22,R21
	21	Grd track determ	R00
	22	Orb nav	R02,R53,R52, R00
	23	Cislunar midcourse nav	R00,R53,R52
	24	Rate aided opt	R00,R53,R52
	27	CMC update	None

Do not select the following program sequences:

a. P3X - P7X - P40/P41
   P3X - P23 - P40/P41
   (P3X computations are overwritten)
   Redo P3X and then P40 or P41

b. P40/P41 - P27 - P52
   (P27 overwrites preferred attitude computations)
   Redo P40/P41 up to V50 N18, then reselect P52

c. P27 - P40/P41 - 52
   Reload preferred REFSMMAT from ground.

STA/T STEP		PROCEDURE	PANEL	REMARKS
Phase	Program No.	Program Title	Contains Crew Interface Routines	
Pre-Thrusting	30	External ΔV	R00	
	32	Co-elliptic seq init (CSI)	R00	
	33	Constant Δalt (CDH)	R00	
	34	Trnfr phase init (TPI)	R00,R22,R21	
	35	Trnfr phase (midcourse)	R00,R22,R21	
	37	Ret to Earth	R00	
Thrusting	40	SPS	R02,R60,R00	
	41	RCS	R02,R60,R00	
	47	Thrust mon	R02,R00	
Align-ment	51	IMU orient determ	R53,R54,R00	
	52	IMU realign	R02,R50,R00 R52, R53, R54, R55	
	53	Back-up IMU orient determ	R56, R54, R00	
	54	Back-up IMU realign	R02, R50, R00 R56, R54, R55	
Entry	61	Entry prep	R02	
	62	CM/SM sep and pre-entry mnvr	R02	
	63	Entry init	None	
	64	Post 0.05 G	None	

CMC PROGRAM - ROUTINE INDEX

STA/T STEP	PROCEDURE	PANEL	REMARKS

Phase	Program No.	Program Title	Contains Crew Interface Routines
	65	Entry upcontrol	None
	66	Ballistic entry	None
	67	Fnl phase	R00
Abort	72	LM co-elliptic seq trgtg (CSI)	R00
	73	LM constant Δalt trgtg (CDH)	R00
	74	LM trnfr phase init (TPI) trgtg	R22,R00,R21
	75	LM trnfr phase (midcourse) trgtg	R22,R00,R21
	76	Trgt ΔV	R00

4.6.8.2 Routines

Routine	Routine Title	REMARKS
00	Fnl auto req term	
02	IMU stat check	Manually selected by crew (V48E).
03	DAP data load	Manually selected by crew (V64E).
05	S bd ant	Manually selected by crew (V57E).
21	Rndz tracking sighting mrk	
22	Rndz tracking data processing	Manually selected by crew (V54E).
23	Backup rndz tracking sighting mrk	May be called by crew (V82E).
30	Orb param disp	

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
Routine	Routine Title		
31	Rndz param disp routine No. 1		Displays range, range rate, and the angle between CSM +X axis and local horizontal (theta). Selected by crew (V83E).
33	CMC/LGC clock sync		V06 N65.
34	Rndz param disp routine No. 2		Displays range, range rate, and angle between optics star line of sight and local horizontal (phi). Selected by crew (V85E).
36	Rndz out of plane disp		Selected by V90E.
40	SPS thrust fail		
41	State vctr integration (mid to ave)		
50	Coarse align		
52	Auto opt positioning		Automatically selected by P20, P22, P23 or P52. It is self-perpetuating and terminated by R53 for star or landmark sightings.
53	Sighting mrk		
54	Sighting data disp		
55	Gyro torquing		
56	Alternate LOS sighting mrk		Used to perform sighting marks for backup alignment programs P53 and P54.
57	Opt calib		
60	Att mnvr		
61	Tracking att		Orients CSM properly with respect to target vehicle during rendezvous tracking.
62	Crew defined mnvr		Selected by (V49E) via P00 only.
63	Rndz fnl att		Selected by (V89E) via P00 only.
64	Orbrate/PTC (BBQ mode - R64)		Selected by (V79E).

CMC PROGRAM - ROUTINE INDEX

STA/T STEP	PROCEDURE	PANEL	REMARKS

4.6.9 CMC PROGRAM - FLAG LISTING

The flags which are applicable to colossus programs are summarized in this section for information purposes only. Paragraph 4.6.9.1 shows the correlation between flag word numbers and erasable memory addresses while paragraph 4.6.9.2 lists the relationship between flags and programs.

4.6.9.1 Flag Word - Memory Location Correlation

Flag Word	Memory Address
0	00074
1	00075
2	00076
3	00077
4	00100
5	00101
6	00102
7	00103
8	00104
9	00105
10	00106
11	00107

4.6.9.2 Flag - Program Listing

No.	Title	Code	Flag Word	Bit	When Set	When Reset
FLAGS						
1	Rndz	RNDVZFLG	0	7	P20 init	P20 term
2	Update	UPDATFLG	1	7	State vctr up-dating by marks allowed	State vctr up-dating by marks not allowed
3	Track	TRACKFLG	1	5	Rndz tracking allowed	Rndz tracking not allowed
4	Pref att	PFRATFLG	2	4	Preferred SC att computed	Preferred SC att not computed
5	Steer	STEERSW	2	11	Steering to be done	Steering omitted
6	IMU orient	REFSMFLG	3	13	REFSMMAT good	REFSMMAT not good
7	IMU	IMUSE	0	8	IMU in use	IMU not in use
8	State vctr	VEHUPFLG	1	8	CSM state vctr updated	LM state vctr updated
9	Term	TERMIFLG	7	15	Term R52 and R53	Do not term
11	Trgt 1	TARG1FLG	1	10	Sighting LM	Not sighting LM
12	Trgt 2	TARG2FLG	1	9	Sighting lmk	Sighting Star
13	W matrix (rndz	RENDWFLG	5	1	W matrix for rndz nav valid	W matrix for rndz nav invalid
14	W matrix (orb nav)	ORBWFLAG	3	6	W matrix for orb nav valid	W matrix for orb nav invalid

No.	Title	Code	Flag Word	Bit	When Set	When Reset
15	3 axis	3AXISFLG	5	6	Mnvr specified by 3 axes	Mnvr specified by 1 axis
16	External ΔV	XDELVFLG	2	8	External ΔV VG computations	Lambert VG computations
17	Active veh	AVFLAG	2	5	LM active	CSM active
18	Final comp	FINALFLG	2	6	Fnl pass thru rndz prog comp	Interim pass thru rndz prog comp
19	Sighting mrk	R53FLAG	0	6	V51 initiated	V51 not initiated
20	Stick flag	STIKFLAG	1	14	RHC out of detent (auto mnvr not enabled)	RHC in detent (auto mnvr enabled)
21	Surface	SURFFLAG	8	8	LM on lunar surface	LM not on lunar surface
22	LM sphere	LMOONFLG	8	11	Permanent LM state in lunar sphere	Permanent LM state in earth sphere
23	CM sphere	CMOONFLG	8	12	Permanent CSM state in lunar sphere	Permanent CSM state in earth sphere
NON-FLAGS						
1	Mrk	MARKSTAT	1344*	10	After sighting mark	After mark reject
2	ISS zero	IMODES30	1334*	9	IMU opr bit present (set to 0)	IMU opr bit not present (reset to 1)

*Memory address

STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.7 G&C REFERENCE MODES		
	This section provides information about basic G&C functions by defining them in terms of system operating prerequisites and switch positions which together represent reference modes. Their scope is limited to independent system functions. These reference modes are repeatable and are applicable to all G&C procedures and thus are referenced in all subsequent sections of G&C procedures. The modes, however, are NOT intended to be complete or self-contained procedures.		
	Wherever a step in one of these G&C reference modes references another mode, the title and paragraph number of the referenced mode is shown and the recommended options in the mode, if any, are specified. Only those switches which are required to be in unique positions are shown in the affected step after the mode is referenced.		
	During time-critical mission phases, reference to other sections of the handbook cannot be accommodated, and, therefore, all time-critical operations are self-contained. Modes similar to those shown in this section, however, are contained or repeated within the time-critical procedures.		
	For general G&C operating data, refer to operating notes, 4.6.1.		
	4.7.1 ATTITUDE CONTROL		
	4.7.1.1 SCS Channel Selection		Provides methods for enabling RCS auto coils without undesirable jet firings.
CDR	1 Set pwr sw LOGIC 2/3 PWR - on (up)	7	Supplies 28 vdc to SC CONT switch, THC CW switch and ATT 1/RATE 2 and RATE 2 positions of BMAG MODE switches.
	SIG CONDR/DR BIAS PWR (both) - AC1 or AC2		4.6.1.2, note 5.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
	2	Enable auto coils		
CDR		For CMC cont SC CONT - CMC CMC MODE - FREE	1	For post CM/SM separation, AUTO RCS A/C ROLL switches should be OFF, and DAP configured for B/D roll. Also refer to 4.6.1.1, note 7.
		MAN ATT (3) - MIN IMP or RATE CMD		4.6.1.1, note 8.
		AUTO RCS (16) - MNA or MNB or OFF (correspond to RCS DAP configuration)	8	Configure AUTO RCS roll enable to agree with RCS DAP load, to reduce SPS propellant slosh during ΔV thrusting in the event of a failed-on roll jet.
		For SCS cont		
		a. SC CONT - SCS	1	
		or SC CONT - CMC THC - CW		
		b. BMAG MODE (3) - RATE 2		BMAG MODE or MAN ATT switching cages BMAGs and prevents attitude error signals from causing jet firings.
		or MAN ATT (3) - MIN IMP or ACCEL CMD		
		c. AUTO RCS (16) - MNA or MNB	8	For SCS control, switches should be set by quad and rotation axis, as desired. Only one roll quad should be enabled for SCS control to optimize RCS propellant consumption. One exception is 3-axis translation when all quads are required.
	4.7.1.2	SCS Minimum Impulse		
	1	Set pwr sw ELEC PWR - GDC/ECA or ECA	7	Either position required for minimum impulse generator.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR		LOGIC 2/3 PWR - on (up) SIG CONDR/DR BIAS PWR (both) - AC1 or AC2	7	Supplies 28 vdc to SC CONT switch, and THC CW switch. 4.6.1.2, note 5.
		RHC PWR NORM (both) - AC/DC	1	
	2	Sel min imp cont MAN ATT - MIN IMP SC CONT - SCS		Switches should be set by axis as desired.
	or	SC CONT - CMC THC - CW		
	3	Enable auto coils, 4.7.1.1		
		4.7.1.3 SCS Acceleration Command		
	1	Set pwr sw LOGIC 2/3 PWR - on (up) SIG CONDR/DR BIAS PWR (both) - AC1 or AC2	7	Supplies 28 vdc to SC CONT switch. 4.6.1.2, note 5.
		RHC PWR NORM (both) - AC/DC	1	
	2	Sel accel cmd cont MAN ATT - ACCEL CMD		Switches should be set by axis as desired. Either CMC or SCS control permissible.
	3	Enable auto coils, 4.7.1.1		
		4.7.1.4 SCS Attitude Hold/Rate Command		
	1	Set pwr sw LOGIC 2/3 PWR - on (up) ELEC PWR - GDC/ECA or ECA	7	Supplies 28 vdc to SC CONT switch.

NORMAL BACKUP

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR		SIG CONDR/DR BIAS PWR 1 - AC1 or AC2	7	Provides SCS signal conditioner power for RHC proportional rate command TLM. Also refer to 4.6.1.2, note 5.
		BMAG PWR (both) - ON		If rate damping only is desired, BMAG 1 need not be turned ON but should be set to WARMUP.
		RHC PWR NORM (1, 2 or BOTH) - AC/DC	1	If manual override of attitude hold desired.
	2	Enable auto coils, 4.7.1.1		4.6.1.1, note 7.
	3	Establish att hold MAN ATT - RATE CMD SC CONT - SCS		Switches may be set by axis as desired. Also refer to 4.6.1.2, note 6.
	or	SC CONT - CMC THC - CW		
		BMAG MODE - ATT 1/RATE 2		
	4.7.1.5	CMC Minimum Impulse		
	1	The following are req CMC - on, 4.8.1.3 RCS DAP - load & activate, 4.8.2.1		CMC, ISS, and RCS DAP enable autopilot control. Minimum impulse controller (MIC), located on panel 122 in LEB, and RHC provides minimum impulse command capability in this mode. RHC will provide normal acceleration commands providing MAN ATT switches at ACCEL CMD.
		ISS - on (desired), 4.8.1.3		For display of ISS total attitude and errors.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
	2	Set pwr sw		
CDR		LOGIC 2/3 PWR - on (up)	7	Supplies 28 vdc to SC CONT switch.
		SIG CONDR/DR BIAS PWR (both) - AC1 or AC2		4.6.1.2, note 5.
		RHC PWR NORM (both) - AC/DC	1	
	3	Establish CMC Cont		
		SC CONT - CMC		
		CMC MODE - FREE		
		MAN ATT (3) - MIN IMP		ACCEL CMD position cannot be used because it inhibits CMC outputs to jets.
		or MAN ATT (3) - RATE CMD		
		BMAG MODE (3) - RATE 2		
	4	Enable Auto Coils, 4.7.1.1		
		4.7.1.6 CMC Attitude Control - Auto/Hold		
	1	The following are req		CMC, ISS, and RCS DAP enable autopilot control.
		CMC - on, 4.8.1.3		
		ISS - on, 4.8.1.3		
		RCS DAP - load & activate, 4.8.2.1		
	2	Set pwr sw		
		LOGIC 2/3 PWR - on (up)	7	Supplies 28 vdc to SC CONT switch.
		SIG CONDR/DR BIAS PWR (both) - AC1 or AC2		4.6.1.2, note 5.
	3	Enable auto coils, 4.7.1.1		
	4	Establish att cont		
		MAN ATT (3) - RATE CMD or MIN IMP	1	

STA/T	STEP	PROCEDURE	PANEL	REMARKS
	1	Set pwr sw		
CDR		FDAI/GPI PWR - 1, 2 or BOTH	7	Provides power for display electronics. Position chosen depends on which FDAI(s) desired.
		LOGIC 2/3 PWR - on (up)		Supplies power for caging BMAGs via BMAG MODE switches.
		BMAG 1 PWR - ON		Powers BMAGs in gyro assembly 1, the only BMAGs capable of providing attitude error information.
	2	Provide att err info		
		MAN ATT - RATE CMD	1	Switches should be set by axis as desired. RATE CMD position required to uncage BMAG 1. However, RHC breakout and MAN ATT switches overridden by IGN 2 logic signal during thrusting to uncage BMAGs.
		BMAG MODE - ATT 1/RATE 2		
		RHC - neut		If RHC breakout switches activated, BMAGs caged (by axis) and attitude hold lost.
	3	Sel disp configuration		
		a. FDAI SEL - 1/2		Displays attitude error from BMAG 1 on FDAI 2.
	or	b. FDAI SEL - 1 or 2		Displays attitude error from BMAG 1 on FDAI 1 or 2.
		FDAI SOURCE - GDC		This position required when only one FDAI selected.
	4.7.2.3	Attitude Error Display - CMC Source		Provides G&N computed attitude error in control axes. Information meaningful only when computer program defines desired attitude.
	1	The following are req		
		CMC - on, 4.8.1.3		Required to compute error and mode CDUs.
		ISS - on, 4.8.1.3		Required for attitude information.
	2	Set pwr sw		
		FDAI/GPI PWR - 1, 2 or BOTH	7	Provides power for display electronics. Position chosen depends on which FDAI(s) desired.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR		LOGIC 2/3 PWR - on (up)	7	Provides power for FDAI switches.
	3	Select disp scaling FDAI SCALE - 5/5 or 5/1	1	Positions provide for compatible scaling between CMC and display electronics in roll axis during orbital flight. If 50/15, 50/10 position is chosen, roll scaling is 12.5° full scale.
	4	Sel disp configuration		
		a. FDAI SEL - 1/2		Displays attitude error from CDUs on FDAI 1.
	or	b. FDAI SEL - 1 or 2 FDAI SOURCE - CMC		Displays attitude error from CDUs on FDAI 1 or 2. This position required when only one FDAI selected.
	4.7.2.4	Attitude Error Display - Attitude Set Source		Provides methods for displaying attitude difference between attitude set indicators and GDC (body error) or IMU gimbal angles (Euler error). Polarity reversal occurs when ATT SET - IMU option selected and roll gimbal angle >±90°. Pitch and yaw attitude error needles become "fly from" indicators rather than "fly to" indicators in this instance.
	1	Set pwr sw & disp logic FDAI/GPI PWR - 1, 2 or BOTH	7	Provides power for display electronics. Position depends on which FDAI desired.
		LOGIC 2/3 PWR - on (up) FDAI SEL - 1 or 2 FDAI SOURCE - ATT SET	1	Display not available at 1/2 position. Required to enable attitude set input to FDAI.
	2	Sel att ref		
		a. SCS ELEC PWR - GDC/ECA BMAG 2 PWR - ON	7	Provides power to GDC electronics.

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	ATT SET - GDC BMAG MODE - RATE 2 or ATT 1/RATE 2	1	Switches should be set by axis as desired.
	b. ISS ISS - on, 4.8.1.3 ATT SET - IMU		4.6.1.1, note 5.
	4.7.2.5 Total Attitude		Provides methods for displaying Euler angles on FDAI ball from GDC or IMU.
	1 Set pwr sw & enable FDAI FDAI/GPI PWR - 1, 2 or BOTH	7	Provides power for display electronics. Position depends on which FDAI(s) desired.
	LOGIC 2/3 PWR - on (up)		Supplies power for FDAI, BMAG MODE switches and ATT SET switch (IMU position).
	2 Sel disp & disp source		
	a. ISS disp ISS - on, 4.8.1.3 FDAI 1 disp		Enables IMU resolver outputs to FDAI 1 ball drive. There are three possible switch combinations.
	FDAI SEL - 1/2	1	This position also enables GDC total attitude to FDAI No. 2.
	or FDAI SEL - 1 FDAI SOURCE - CMC		
	or FDAI SOURCE - ATT SET ATT SET - IMU		4.6.1.1, note 5.
	FDAI 2 disp FDAI SEL - 2 FDAI SOURCE - CMC		Enables IMU resolver outputs to FDAI 2 ball drive. There are two possible switch combinations.

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	or FDAI SOURCE - ATT SET ATT SET - IMU	1	4.6.1.1, note 5.
	b. GDC disp ELEC PWR - GDC/ECA	7	Provides power to GDC electronics.
	BMAG 2 PWR - ON BMAG MODE - RATE 2 or ATT 1/RATE 2	1	Switches should be set by axis as desired.
	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx		
	BMAG 1 PWR - ON (if BMAG 2 fails)	7	
	BMAG MODE - RATE 1	1	
	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx		
	FDAI 2 disp FDAI SEL - 1/2		Enables GDC resolver outputs to FDAI 2 ball drive. There are three possible switch combinations.
	or FDAI SEL - 2 FDAI SOURCE - GDC		
	or FDAI SOURCE - ATT SET ATT SET - GDC		
	FDAI 1 disp FDAI SEL - 1 FDAI SOURCE - GDC		Enables GDC resolver outputs to FDAI 1 ball drive. There are two possible switch combinations.
	or FDAI SOURCE - ATT SET ATT SET - GDC		

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.7.2.6	ORDEAL - Local Horizontal Attitude		Provides methods for displaying local horizontal reference established by ORDEAL on FDAI 1 and/or FDAI 2 balls. Only pitch axis is affected.
1	Set pwr sw		
	FDAI/GPI PWR - 1, 2 or BOTH	7	Provides power for display electronics. Position chosen depends on which FDAI(s) desired.
	EARTH/LUNAR - EARTH or LUNAR	13	
	LTG - BRT or DIM		
2	Sel disp configuration		Reference system may be GDC or IMU, 4.7.2.5.
	FDAI 1 disp		
	FDAI SEL - 1 or 1/2	1	
	FDAI 1 sw - ORB RATE	13	
	FDAI 2 disp		
	FDAI SEL - 2 or 1/2	1	
	FDAI 2 sw - ORB RATE	13	
	FDAI 1 & 2 disp		
	FDAI SEL - 1/2	1	
	FDAI sw (both) - ORB RATE	13	
4.7.3	GDC ALIGN		Aligns GDC to ATT SET thumbwheels.
	ELEC PWR - GDC/ECA	7	Supplies power to GDC electronics.
	ATT SET - GDC	1	Enables att set inputs to GDC.
	Verify tw settings		
	GDC ALIGN pb - push		Enables attitude set inputs to GDC and disables BMAG inputs.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.7.4 SPS THRUST CONTROL		
		4.7.4.1 TVC Initialization		Defines safe switch configuration required before initiation of thrusting procedures.
CDR		LOGIC 2/3 PWR - on (up)	7	Provides power to SCS TVC switches. Required for RCS jet on-off and MTVC TLM.
		SIG CONDR/DR BIAS PWR (both) - AC1 or AC2		
		SPS THRUST - NORM	1	
		SCS TVC (2) - RATE CMD (if burn is G&N or MTVC)		
	or	SCS TVC (2) - AUTO (SCS burn)		
		TVC GMBL DR (2) - AUTO		The 1 or 2 positions may be used as backup if required.
		ΔV CG - LM/CSM or CSM		Required only for SCS/SPS auto thrusting. Position depends on whether LM attached or not.
		FDAI/GPI PWR - 1, 2 or BOTH	7	Position chosen depends on whether redundant GPI displays desired. To enable redundant GPI indicators, FDAI/GPI PWR switch must be set to BOTH.
		LV IND/GPI sw - GPI	1	
		4.7.4.2 SPS Gimbal Control		
	1	CMC Cont		Provides attitude information and power to ECDUs.
		ISS - on (req), 4.8.1.3		
		CMC - on (req), 4.8.1.3		
		Servo loop activated (step 4)		
		Gmbl mot on		Operating time limited depending on operating conditions. MN BUS TIE (2) must be on before gimbal motors started.
		SC CONT - CMC		

NORMAL/BACKUP

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR		LOGIC 2/3 PWR - on (up) THC - neutral	7	Supplies power to SC CONT switch.
	2	SCS Cont - AUTO Servo loop activated (step 4) Gmbl mot on	1	Operating time limited depending on operating conditions. MN BUS TIE (2) must be on before gimbal motors are started.
		LOGIC 2/3 PWR - on (up)	7	Supplies power to SC CONT, BMAG MODE, SCS TVC, .05 G switch (OFF position) and THC CW switches.
		ELEC PWR - ECA or CDC/ECA **BMAG PWR (both) - ON**		**Supplies power to the control electronics.** **Rate and attitude sensors required.**
		BMAG MODE - ATT 1/RATE 2	1	BMAGs in gyro assembly 1 will uncage if MAN ATT switches are at RATE CMD. If not, uncaging will occur when IGN 2 logic signal is present.
		SCS TVC (2) - AUTO IGN 2 logic sig present		Provided by thrust control logic at engine on until 1 second after engine off.
		SC CONT - SCS THC - neut		
	or	SC CONT - CMC THC - CW		
	3	MTVC cont - RATE CMD/ACCEL CMD		Stick integrator is enabled when IGN 2 logic signal is present. IGN 2 logic signal present at SPS on until 1 second after SPS - off, is provided by thrust control electronics.

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	Servo loop activated (step 4) Gmbl mot on		Operating time limited depending on operating conditions. MN BUS TIE (2) must be on before gimbal motors started.
	LOGIC 2/3 PWR - on (up)	7	Provides power for SC CONT, BMAG MODE, SCS TVC and THC - CW switches.
	SIG CONDR/DR BIAS PWR (both) - AC1 or AC2 ELEC PWR - ECA or GDC/ECA BMAG 2 PWR - ON (for RATE CMD) BMAG MODE (3) - ATT 1/RATE 2 or RATE 2 RHC PWR NORM (both) - AC/DC	1	Required for RCS jet on-off and MTVC TLM. Supplies power to RHCs and control electronics. Rate information required for RATE CMD MTVC.
	Rate Cmd		
	a. SCS TVC (2) - AUTO SC CONT - SCS THC - CW		
or	b. SCS TVC (2) - RATE CMD SC CONT - SCS		
	or SC CONT - CMC THC - CW		
	Accel Cmd		
	a. SCS TVC (2) - ACCEL CMD SC CONT - SCS		
	or SC CONT - CMC THC - CW		

NORMAL/BACKUP

STA/T	STEP	PROCEDURE	PANEL	REMARKS
	4	Servo Loop Activation		
		a. Servo loop No. 1		
CDR		TVC SERVO PWR 1 - AC1/MNA	7	Provides power to clutches and servo drive electronics. Alternate position of this switch (AC2/MNB) should be used only in the event of an AC1 bus failure to provide additional redundancy. AC1/MNA position should be used in all other cases to be compatible with d-c power source for gimbal motors (DC MNA bus power).
		TVC GMBL DR (2) - 1	1	
		or TVC GMBL DR (2) - AUTO THC - neut GMBL MOT 1 - operating		No. 1 gimbal motor must be on with no overcurrent failure sensed.
		or TVC SERVO PWR 2 - OFF	7	
		b. Servo loop No. 2		
		TVC SERVO PWR 2 - AC2/MNB		Alternate position of this switch (AC1/MNA) should be used only in the event of an AC2 bus failure to provide additional redundancy. AC2/MNB position should be used in all other cases to be compatible with d-c power source for gimbal motors (DC MNB bus power).
		TVC GMBL DR (2) - 2	1	
		or TVC GMBL DR (2) - AUTO LOGIC 2/3 PWR - on (up) THC - CW	7	Provides power to THC - CW switch.
		or TVC GMBL DR (2) - AUTO GMBL MOT 1 - not operating	1	If No. 1 gimbal motor is off or an overcurrent sensed, control transferred to No. 2 servo loop.

STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.7.4.3 Thrust On-Off Control		
1	CMC Cont		
	ISS - on (req), 4.8.1.3		
	CMC - on (req), 4.8.1.3		
	SPS Gmbl Cont (desired), 4.7.4.2		
	SC CONT - CMC		To satisfy CMC control, THC must not be CW.
	LOGIC 2/3 PWR - on (up)	7	Supplies 28 vdc to SC CONT switch.
	SPS THRUST - NORM	1	DIR ON will override CMC thrust-on control.
	ΔV THRUST A(B) - NORM		Guarded.
	Thrust on		
	CMC eng on cmd (P40)		
	Thrust off		
	CMC eng off cmd (P40)		
	or ΔV THRUST A &/or B - OFF		Guarded.
2	SCS Cont		
	SPS Gmbl Cont (desired), 4.7.4.2		
	SC CONT - SCS		
	or SC CONT - CMC		This option may establish SCS MTVC mode depending on position of SCS TVC switches.
	THC - CW		
	LOGIC 2/3 PWR - on (up)	7	Supplies 28 vdc to SC CONT switch.
	SPS THRUST - NORM	1	DIR ON will override SPS thrust control.
	ΔV THRUST A(B) - NORM		Guarded.
	Thrust on		
	ΔV ind - not zero		Required only if EMS FUNC in ΔV or ΔV TEST.
	THC - +X		

NORMAL/BACKUP

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR		or DIR ULL pb - push	1	
		THRUST ON pb - push		
		Thrust off		
		EMS FUNC - ΔV		
		ΔV ind - zero		
		or ΔV THRUST A &/or B - OFF		Guarded.
	3	Dir Cont		
		SPS Gmbl Cont (desired), 4.7.4.2		
		Thrust on		
		ΔV THRUST A &/or B - NORM		Guarded.
		SPS THRUST - DIR ON		Lever lock.
		Thrust off		
		ΔV THRUST A &/or B - OFF		Guarded.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.7.5 OPTICS CONTROL		
		4.7.5.1 Auto Optics Positioning		This procedure permits CMC control of optics.
	1	The following are req ISS - on, & orient known, 4.8.1.3 & 4.14 CMC - on, 4.8.1.3 Opt - on, 4.8.1.4		
	2	Establish CMC cont		
CMP		OPT ZERO - OFF	122	
		OPT TELTRUN - SLAVE TO SXT		Required for SCT trunnion drive.
		OPT MODE - CMC		
		4.7.5.2 Manual Optics Control		Permits manual control of optics using optics hand control (OHC).
	1	Opt - on, 4.8.1.4		
	2	Establish man cont & sighting options		
		OPT ZERO - OFF		
		OPT COUPLING - DIR or RSLV		Permits desired image motion in FOV. In DIRECT mode, OHC left, right motion drives optics shaft, while up, down motion drives trunnion. RSLV mode provides motion resolved into SC body coordinates. Motion appears to be target motion corresponding to direction of OHC movement.
		OPT MODE - MAN		
		OPT TELTRUN - SLAVE TO SXT		Required for proper landmark tracking.
	or	0°		Provides zeroing of SCT trunnion axis.
	or	25°		Provides greater scanning capability for star sightings.
		OPT SPEED - HI, MED or LO		Set as desired.

STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.7.5.3 Manual Optics Drive		Permits manual optics operation (no power) using optics tool.
	1 The following are req		
LMP	G/N PWR - AC1 or AC2	5	Supplies power for condition lamps and reticle.
CMP	G/N OPT PWR - OFF	100	
	2 Obtain opt tool from tool kit		
	3 Perform man opt drive		
	RETCL BRT tw - as req	122	
	SHAFT - as desired	121	
	TRUN - as desired		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.7.6 ENTRY MONITOR SYSTEM (EMS)		
		4.7.6.1 ΔV Test & Null Bias Check		
CDR	1	Init EMS prep EMS FUNC - OFF (verify) cb EMS (2) - close EMS MODE - STBY	 1 8 1	
	2	EMS FUNC - ΔV SET Adj alphanumeric brightness (option) EMS MODE - NORM Set ΔV ind to +1586.8 fps		Enables slewing of ΔV indicator. 4.6.1.1, note 9.
	3	EMS FUNC - ΔV TEST SPS THRUST lt - on ΔV ind decr (10 sec) SPS THRUST lt - out ≈-0.1 fps on ΔV ind ΔV ind stops at -20.8±20.7 fps		ΔV TEST checks ΔV circuitry.
	4	EMS MODE - STBY		
	5	EMS FUNC - ΔV SET Slew ΔV ind to -100.0 fps		The ΔV indicator zeroed to start accelerometer null bias check.
	6	EMS FUNC - ΔV (wait 5 sec)		
T=0	7	EMS MODE - NORM		

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR T=100 sec 8	EMS MODE - STBY Rcd ΔV ind	1	
	If ΔV drift ≤1 fps, do not bias counter		Acceleration ≤0.01 fps2.
	If ΔV drift >1 fps but <10 fps bias if desired		Acceleration ≥0.01 fps2 but <0.1 fps2. Counter bias not required for SPS ΔV.
	If ΔV drift >10 fps, EMS is no-go for all functions		Acceleration >0.1 fps2.
	CAUTION Do not turn EMS FUNC - OFF prior to ΔV, or null bias will be invalid.		
4.7.6.2	ΔV Setup		Specifies required steps necessary to initialize EMS for monitoring ΔVs and to generate SPS engine cutoff signal for SCS controlled SPS ΔVs.
	ΔV TEST & NULL BIAS CHECK (desired), 4.7.6.1 cb EMS (2) - close	8	
1	EMS MODE - STBY EMS FUNC - ΔV SET	1	
2	Set ΔV ind - req ΔV		
3	EMS FUNC - ΔV		4.6.1.1, note 9.

STA/T STEP	PROCEDURE	PANEL	REMARKS

4.8 G&C GENERAL PROCEDURES

The procedures in this section involve both the G&N and SCS and are used most frequently during the orbital phase. Because they are fundamental to G&C operation, they are included or referenced in various forms in the more complex G&C procedures contained in sections 4.9 and 4.11 through 4.18.

Applicable G&C Reference Modes, 4.7, have been referenced throughout these procedures.

For general G&C operating data, refer to operating notes, 4.6.1.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.1 G&N GENERAL		
		4.8.1.1 (P00) CMC Idling Program		Indicates that CMC in operate condition but not performing control or computation operations requiring coordination with other crew tasks. Maintains CMC in readiness for entry into most programs. CSM and LM state vectors and W-matrices (orbital and rendezvous) are updated. (Refer to 5.6.12 of R-577, section 5.)
CMP		Key V37E 00E DSKY - P00	2,140	
		4.8.1.2 CMC/IMU Power Down		
		(P06) CMC Power Down		Transfers CMC from operate to standby. V69E may be used to recover from an inadvertent entrance into P06. Otherwise, when P06 selected, CMC must be powered down to standby.
		Perform DAP Activation, 4.8.2.1 Load 0 (no DAP) in left digit of R1		Prevents inadvertent jet firing during power up.
	1	Key V37E 06E DSKY - P06		
	2	FL V50 N25 00062 (CMC pwr down)		
		PRO (push till STBY lt - on) **CMC blanks DSKY dis**		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		IMU Power Down		Transfers IMU from operate to standby.
CDR	1	CMC MODE - FREE	1	
CMP	2	G/N IMU PWR - OFF	100	Guarded. Loss of IRIG wheel power will send IMU FAIL discrete to CMC.
	3	If CMC operating Key V37E XXE	2,140	Select program not requiring IMU.
		CAUTION		
		Only in case of emer shall IMU be powered down beyond stby:		If standby power removed for >20 minutes, ISS calibration no longer valid.
LMP		cb IMU HTR (2) - open	5	
	4.8.1.3	Startup		Transfers ISS/CMC from standby to operate condition. Startup procedure will be first procedure selected after returning from standby, since time 2/time 1 is invalid until this is done.
		CMC Startup		
CMP		PRO - (push until STBY lt out) Poss CMC warning lt (20 sec max) Poss RESTART lt - on Poss PROG alarm RSET DSKY - P06 FL V37 Key 00E	2,140	When PRO released, CMC may revert to STBY mode. Repeat PRO until STBY light out. These alarms should be ignored if they can be reset.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		If state vctr update		
CMP		Key V96E	2,140	V96E suspends state vector integration.
		Perform CSM - (P27) CMC Update, 4.8.1.5		
		Key V37E 00E		Re-enables P00 integration suspended by V96E.
		Key V37E XXE		
		ISS Startup		
		If CMC on		
		G/N IMU PWR - on (up)	100	Guarded.
		NO ATT lt - on (90 sec)	2,140	
		NO ATT lt - out (wait 15 sec)		
		Key V37E XXE		Select IMU alignment program desired.
		If CMC not on		
		G/N IMU PWR - on (up)	100	Guarded. IMU drives to 0,0,0.
		Wait 90 sec		
CDR		IMU CAGE - on (up) ≈5 sec then off (down)	1	Guarded. Releases IMU.
	4.8.1.4	Optics Power Control		
	1	Opt pwr up		
CMP		G/N PWR - AC1 or AC2	5	Provides power to reticle and condition lights in LEB.
		G/N OPT PWR - on (up)	100	
		OPT ZERO - OFF	122	OPT ZERO switch should be left at ZERO until optics use required. It is not position of this switch, but change to ZERO position that triggers zeroing routine.
		OPT ZERO - ZERO (≈15 sec to zero)		
		COND LAMPS - ON		
		RETCL BRT tw - adj		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
	2	Opt pwr down		
CMP		OPT ZERO - ZERO	122	
		G/N OPT PWR - OFF	100	
		G/N PWR - OFF	5	Removes power from reticle and condition lights in LEB.
		4.8.1.5 (P27) CSM - CMC Update		P27 may be entered only from P00, P02. All uplinked or keyed in ΔVs and target vectors must be in same sphere of influence as CMC determined state at TIG and TIG -30.
		CMC - on (req), 4.8.1.3		
		Key V37E 00E	2,140	
		Auto Update		
	1	UP TLM CM - ACPT	2	
		UP TLM - ACPT	122	
		UPLINK ACTY lt - on		
	2	Update complete		
		UPLINK ACTY lt - out	2,122	PROG window on DSKY displays 00 or 02.
		UP TLM CM - BLOCK	2	
	or	UP TLM - BLOCK	122	
	3	Key V37E 00E	2,140	
		Voice Transmission Update		
	1	Liftoff time - V70E		
	or	Load data block - V71E		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	or	Load singular data - V72E	2,140	
	or	Oct time increment - V73E		
		Poss OPR ERR		If another extended verb active.
	2	DSKY - P27		P27 may be terminated by responding to flashing display with V34E. Data will not be incorporated for use by CMC.
	3	FL V21 N01 R1 Blank R2 Unchanged R3 AAAAA		
		Key in update data, XXXXXE (R1) CMC increments R3 by 1		
		Repeat 3 until all data loaded		
	4	FL V21 N02 R1 Blank R2 Unchanged R3 00330		
		Accept update V33E		4.6.1.3, note 3m.
		P00 or P02 - sel auto		Data transferred from buffer storage to appropriate cells
		If V96 previously keyed Key V37E 00E		Reinstates periodic P00 integration.
		Reject update Load Oct ID (XXE) of word to be corrected Return to 3		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		Time Update (Decimal)		
CMP	1	Key V55E	2,140	
		Poss OPR ERR		If another extended verb active.
	2	FL V21 N24 (V25)		All registers initially blank.
		Δ time (CMC clock) 00XXX. HRS 000XX. MIN 0XX.XX SEC		Delta time change must all be provided in decimal.
		Accept Load ΔT		CMC adds ΔT to CMC clock time.
		Reject V33E		4.6.1.3, note 3m. V33E or V34E does not update clock time.
		or V34E		
	3	Check Updated CMC Time Key V06 N65E Key V37E 00E		DSKY displays R1, R2, R3 for crew verification. CMC returns to P00.
		Erasable Memory Update		
	1	Key V37E 00E		
	2	For Seq Address V21 N01E Load first address XXXXE Load first data word XXXXXE		
		N15E Verify CMC increments address by one (R1)		

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Load second data word XXXXXE,E Load third data word XXXXXE,E Continue until last address in seq filled	2,140	
	3 For Non-seq Address V21 N01E Load first address XXXXE Load first data word XXXXXE,E Load second address XXXXE Load second data word XXXXXE,E		
	4 To Verify Data Loaded in Seq Address V01 N01E Load first address XXXXE Check first data word in R1 N15E Check second data word in R1 ENTR Check third data word in R1 ENTR		
	4.8.1.6 <u>(P47) G&N Thrusting Monitor Program</u> CMC - on (req), 4.8.1.3 ISS - on & aligned (req), 4.8.1.3 & 4.14		Monitors vehicle acceleration during non-G&N controlled thrusting maneuvers, and displays ΔV applied to vehicle by thrusting maneuver.
	1 Key V37E 47E	2	G&N monitor of ΔV highly desirable, if available, but not a requirement. P47 should be called just prior to thrusting and terminated as soon as possible

...continued

STA/T STEP	PROCEDURE	PANEL	REMARKS
			thereafter in order to minimize errors of bias and average G. P47 also normally used during rendezvous final phase. Any ΔV under G&N control during that phase would require P34, P40, or P41. Range, range rate, and theta may be displayed by using V83 (R31). Range, range rate, and phi may be displayed during P47 by using V85 (R34). Orbital parameters may be displayed by using V82 (R30). Also, an SCS orbit change can be monitored by P40 if properly combined with G&N Prethrusting and Thrusting Procedures, 4.12 and 4.13. N62 (VI, H dot, H) available during P47.
	Poss PROG alarm (4.8.1.16)		R02.
CMP 2	FL V16 N83 ΔVX, Y, Z (cont) XXXX.X FPS	2	Displayed when average G turned on. CMC requires 12.5 seconds to turn on average G if integration required is < a time step plus 1.4 seconds (earth orbit) or 2.5 seconds (lunar orbit) for each additional time step. Time step = 240 seconds (earth orbit) or 350 seconds (lunar orbit).
	(To rezero registers - V32E)		Provides capability to monitor another burn without going through R00.
	Mon for furn completion Rcd ΔV PRO (exit P47)		When P47 termination desired.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	3	FL V37 Key XXE	2	If average G on, R00 turns off average G, zeros rendezvous optics mark and VHF ranging mark counters. Otherwise, counters not zeroed. It also sets or resets RNDZ, TRACK, and UPDATE flags, depending on which programs in progress or called. It may also recycle into P20.
		4.8.1.7 CMC Self-Check Procedure		Procedure used to check CMC's ability to write into and read out of erasable memory and performs internal fixed memory banksum.
		CMC - on (req), 4.8.1.3		
	1	Key V25 N01E 1365E E, E, E	2,140	Zero self-check cells: ERCOUNT, SCOUNT, SCOUNT +1.
	2	Key V15 N01E - establish mon of self-check 1365E		Begin monitor of self-check cells.
	3	Key V21 N27E 10E - starts self-check		Starts complete self-check.
	4	Mon R2 & PROG lt		
		a. R2 becomes $\geq$3 Self-check has been successfully completed at least once Key V21 N27E 0E term self-check		Turns off self-check.
		b. If PROG lt comes on Coord with MSFN &/or perform malfunc SSR-1		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.1.8 Measurement and Loading of PIPA Bias		
		CMC - on (req), 4.8.1.3 ISS - on (req), 4.8.1.3 & 4.14		ISS should be on at least one hour prior to performing this procedure to allow PIPAs to stabilize.
		SCS - on (desired), 4.8.4.2		Provides display and SCS control capability.
CDR		LOGIC 2/3 PWR - on (up)	7	
	1	Set Evnt Tmr 00:00	1	
	2	Sel Att Cont desired, 4.7.1 Maintain SC Rates <0.1°/sec		
CDR,CMP 00:00	3	Key V25 N21E, E, E, E/start Evnt Tmr	2,140	Zeros noun 21 cells.
CMP	4	Key V06 N21 (do not ENTR)		
01:04	5	Key ENTR		
	6	Rcd PIPA counts (X)R1____(Y)R2____(Z)R3____ XXXAB		
	7	Key V21 N01E (adj PIPA bias) Load 1452E (calculated X bias) ±ABXXXE, E 1454E (calculated Y bias) ±ABXXXE, E 1456E (calculated Z bias) ±ABXXXE		

NORMAL/BACKUP

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		(If AB >99, CMC incapable of adj PIPA bias)		
CMP	8	Key V37E 00E	2,140	
		4.8.1.9 (R33) CMC/LGC Clock Sync Routine		Provides onboard method of determining difference between LGC and CMC clock time (ΔT).
		CMC - on (req), 4.8.1.3		
	1	Key V06 N65		
	2	Confirm sel of this routine in LM		
	3	Perform countdown with LM crew ENTR (simultaneously with LM)		
	4	V06 N65 CM clock time 00XXX. HRS 000XX. MIN 0XX.XX SEC Rcd this time Obtain from LM the LM clock time of ENTR Compute ΔT If more data req, return to 3 Comp average of ΔTs		
	5	To incorporate ΔT into CMC clock Perform Time Update, 4.8.1.5		

STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.8.1.10 <u>ΔR and ΔV Threshold Change Procedure</u> CMC - on (req), 4.8.1.3		
CMP	Key V24 N01E Key 2002E Load erasable value for desired ΔR (from following table) R3 2003 Load erasable value for desired ΔV (from following table)	2,140	
	4.8.1.11 <u>A or B Erasable Value Change Procedure</u> CMC - on (req), 4.8.1.3 P35 & P75 not operating		Procedure ineffective if programs currently running.

Desired ΔR NM	Erasable Value	Desired ΔV FPS	Erasable Value
0.00	77776	0.00	77776
0.001	0	0.0001	0
0.1	6	2.5	1
0.2	14	5.12	2
0.3	21	7.68	3
0.4	27	10.24	4
0.5	35		

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Key V24 N01E Key 2021E (2023E for B) Load 00000E (1:30 to 2:30) Load 00003E (10:00) Load 00004E (11:00 & 12:00) R3 2022 (2024 for B) Load desired value (from following 2022/2024 table)	2,140	Addresses 2021 and 2023 used by programs P35 and P75 respectively. Addresses 2022 and 2024 used by programs P35 and P75 respectively.

Desired A or B	2022/2024
1:30	21450
1:45	24404
2:00	27340
2:15	32274
2:30	35230
10:00	25140
11:00	00720
12:00	14500

4.8.1.12 Flagword Monitor and Change Procedure

Flagword Monitor

Key V11 N01E
Key XXXE (flagword address) — 4.6.13.1 for flagword addresses.

R1 XXXXX (flag bit)
R3 00XXX (flagword address)

Check flag bit in R1
KEY REL

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		Flagword Change		
CMP		Key V25 N07E Key XXXE (flagword address)	2,140	ECADR ≤30 (octal) will select appropriate channel (except that channel 7 attempts will be ignored).
		Key XXXXXE (bit ID) Key 1 or 0 (1 = set flag bit, 0 = reset flag bit)		Load code for bit to be changed as follows:
		Example:		
		To set REFSMMAT FLG (flagword 3, bit 13) Key V25 N07E 77E 10000E 1E		
		4.8.1.13 (V79) Orbrate/PTC (BBQ Mode - R64)		Allows orbital rate or PTC maneuver by astronaut selection of rate, deadband, and X or Y axis and sets DAP parameters to maintain chosen rate. For SCS passive thermal control procedures, refer to 4.8.4.9 and 10.
		CMC - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14 (For orbrate, Ysm aligned to V x R) SCS - on (desired), 4.8.4.2 RCS DAP - Load & activate (req), 4.8.2.1		Provides display and SCS control capability. 0.5° deadband and 0.2°/second rate recommended.
CDR		LOGIC 2/3 PWR - on (up)	7	
CMP	1	Perform (V49E) R62, 4.8.3.4 Load gmbl angles for init of mnvr (orbrate or PTC)		MGA should be ≈zero for both cases.

	A			B			C			D			E		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
code	4	2	1	4	2	1	4	2	1	4	2	1	4	2	1

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	2	Disable two adjacent RCS quads		Provides fuel conservation and lower rates (panel 8 switches, or R03, may be used to disable engines).
		For PTC, att hold for 20 min		To damp existing vehicle rates.
CDR		MAN ATT P&Y (2) - ACCEL CMD Enable all jets	1	Protects against a pitch or yaw jet firing between end of 20-minute wait period and PRO on N79.
CMP	3	Key V79E	2,140	
		Poss OPR ERR		If another extended verb active.
		If in P00, go to 5		
	4	FL V06 N16 Time of event 00XXX. HRS 00XX. MIN 0XX.XX SEC		Permits loading of GET for maneuver initiation. Initially 00000 (present time).
		Accept PRO Reject V25E Load desired data		
	5	FL V06 N79 Rate X.XXXX DEG/SEC DBD XXX.XX DEG		+ for increasing CDU angles; - for decreasing CDU angles.
		Axis option (X or Y) 0000X. (0 = X axis, non-zero = Y axis)		X axis (PTC), Y axis (orbrate).
CDR		Accept SC CONT - CMC CMC MODE - AUTO	1	
CMP		PRO	2,140	Initiates pitch rate (orbrate), or roll rate (PTC), as determined by N79 load. If GET specified (non-zero) in N16, UPLINK ACTY lt will indicate maneuver initiation. KEY REL, ERR RSET or V37E XXE will extinguish light.
		Reject Key V25E Load desired data		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR		For PTC, MAN ATT ROLL - ACCEL CMD MAN ATT P&Y (2) - RATE CMD	1	Enables auto pitch and yaw attitude hold in N79 deadband.
	6	If desired for PTC, AUTO RCS (16) - OFF RHC PWR DIR (both) - OFF	8 1	Prevents inadvertent direct coil jet firings.
	7	To term mnvr		
CMP		Orbrate Key V46E	2,140	Sets last specified R03 parameters in RCS DAP. In addition, the DAP established by this routine will be altered according to the following table:
		PTC		
CDR		MAN ATT (3) - ACCEL CMD AUTO RCS (16) - MNA or MNB V46E or cycle SC CONT sw MAN ATT (3) - RATE CMD	1 8 1	

SWITCHING FUNCTION	ZEROS COMMANDED RATES	RETURNS TO (R03) SPECIFIED DEADBAND	ZEROS DAP ATTITUDE ERROR
V46E	X	X	X
SC CONT - Cycled, CMC/SCS/CMC	X	X	X
CMC MODE - HOLD	X		X
RHC - out of detent	X		X
V37E XXE	X	X	
KALCMANU	*		X

*KALCMANU generates new commanded rates.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.1.14 G&N Passive Thermal Control Procedure		For SCS passive thermal control procedures, refer to 4.8.4.9 and 10.
		CMC - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14 RCS DAP - Load & activate (req), 4.8.2.1		0.5° deadband and 0.2°/second rate recommended.
	1	Perform (V49E) R62, 4.8.3.4 (PRO on auto mnvr req, FL V50 N18)		This option required to ensure erasable memory is properly set up.
CDR CMP	2	Disable two adjacent RCS quads Att hold for 20 min	8	Provides fuel conservation and lower rates (panel 8 switches or R03 may be used to disable engines).
CDR	3	MAN ATT P&Y (2) - ACCEL CMD Enable all RCS jets	1 8	
CMP	4	Set att hold Key V21 N01E 1013E, E (Set HOLD FLG zero)	2,140	Sets HOLD FLG zero and inhibits maneuver until after data load.
		Establish desired rate		

+0.1°/sec	-0.1°/sec	+0.3°/sec	-0.3°/sec
V24 N01E	V24 N01E	V24 N01E	V24 N01E
3125E	3125E	3125E	3125E
3E	77774E	12E	77765E
24400E	53400E	35400E	42400E
V21E	V21E	V24E	V24E
3176E	3176E	3175E	3175E
35101E	42676E	2E	77775E
		27303E	50474E

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	5	Start roll mnvr Key V21 N01E 1013E 70000E	2,140	Initiates maneuver.
CDR	6	MAN ATT ROLL - ACCEL CMD	1	Disables roll jets for duration of PTC.
CMP	7	Perform RCS DAP Att Dbd Change, 4.8.2.2		±30° deadband is recommended.
CDR	8	AUTO RCS (16) - OFF		
	9	To term PTC MAN ATT (3) - ACCEL CMD (verify) AUTO RCS (16) - MNA or MNB V46E or Cycle SC CONT sw MAN ATT (3) - RATE CMD	 8 1	Re-establishes attitude hold within attitude deadband selected in R03.
	4.8.1.15	Saturn Rate Change		
		CMC - on (req), 4.8.1.3		
CMP	1	Key V24 N01E 3322E XXXE YYYYYE	2,140	

STA/T STEP	PROCEDURE	PANEL	REMARKS

SIVB RATE	SAT RATE +1 (3322) XXX	SAT RATE +2 (3323) YYYYY
0.05°/sec RPY	161	77616
0.1°/sec RPY	210	77567
0.2°/sec RPY	266	77511
*0.3°/sec RPY	344	77433
0.5°/sec R, 0.3°/sec P&Y	476	77301

*Use for TLI

4.8.1.16 (R02) IMU Status Check

Check whether IMU on and, if on, whether it is aligned to an orientation known by CMC. R02 automatically called by programs requiring ISS. Provides for program alarms if ISS not on and/or IMU orientation unknown.

1 ISS not on (known orient not req)

CMP — PROG alarm — 2,140 — Occurs only if ISS not on.

FL V37

Key V05 N09E (to verify alarm)

00210 (ISS not on)

Perform ISS turnon

Alarm stored; must key V05 N09E to display alarm code.

Key XXE

Return to PXX at completion of ISS turnon.

STA/T STEP	PROCEDURE	PANEL	REMARKS
	2 ISS not on &/or orient unknown (known orient req)		
CMP	PROG alarm	2,140	Alarm stored; must key V05 N09E to display alarm code.
	Key V05 N09E (to verify alarm) 00210 (ISS not on)		
	or 00220 (IMU orient unknown)		
	FL V37		RSET and KEY REL pressed when nature of problem determined. When CMC regains control, program cycles through R00, which resets 3-AXIS flag and may set or reset RNDZ, TRACK, and UPDATE flags, depending on which programs are in progress or called.
	Key XXE		Perform ISS turnon and/or IMU orientation determination. Reinitiate desired program.
	4.8.1.17 (V64) S-Band Antenna Routine (R05)		Computes and displays two steerable S-band antenna gimbal angles required to point antenna toward center of earth.
	CMC - on (req), 4.8.1.3		
	ISS - on & orient known (req), 4.8.1.3 & 4.14		Required for valid angle displays.
	1 Key V64E		Selects R05. Uses permanent state vector for calculations and therefore, will be based on old values if average G on.
	Poss OPR ERR		If another extended verb active.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	2	FL V06 N51 Rho XXX.XX DEG Gamma XXX.XX DEG **Accept** Rcd angles PRO **Reject** Sel Att Cont mode desired, 4.7.1 Mnvr SC as req	2,140	S-band required gimbal angles. Rho - Pitch gimbal angle. Gamma - Yaw gimbal angle. Spacecraft maneuver will be required only if displayed angles do not provide an unobstructed view of earth. (Ref CSM Data Book, section 4.7, HGA Scan and Warning Limit, Yaw - Pitch Coord.)

4.8.1.18 DSKY 88888 Clear Procedure

DSKY relay failure mode will cause an all-eights display on DSKY. Affects display capability of DSKY but will not affect input/output or control functions.

Key V99 N99
Key V25 N01E
00000E
+99999E
+99999E
+99999 CLR, CLR, CLR
00000E
00000E
00000E

If OPR ERR
Start over

If DSKY does not clear
Repeat proced

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.2 DIGITAL AUTOPILOT (DAP)		
		4.8.2.1 (V48) CSM - DAP Data Load Procedure (R03)		For CMC control modes, DAP data load procedure is used to select rate, deadband, and quads. When under computer control, operating program will establish SC rates and attitude error deadbands, or crew may select other desired error deadbands via DSKY. In addition, crew has capability of selecting RCS quads for computer command of manual translation, attitude hold, or automatic and manual manuvers.
		CMC - on (req), 4.8.1.3		
CMP	1	Key V48E	2,140	Extended verb 48 program calls DAP data 1, 2, and 3 in sequential order. DAP data 1, 2, or 3 may also be displayed individually by using respective verb/ noun combinations, i.e., V04 N46, V06 N47, or V06 N48.
		(Bit A of R1 configures TVC DAP for LM on-off)		
	2	FL V04 N46 R1 - A B C D E R2 - A B C D E		
		Accept PRO Reject V24E load desired data		

STA/T STEP	PROCEDURE	PANEL	REMARKS
	R1 / R2 table (see below)		If quads A/C and B/D (4 jets) desired for +X translation, R1-B and R1-C may be set to 0,0, or 1,1.
			If A is failed, CMC assumes C is good. If B is failed, CMC assumes D is good.
CMP 3	FL V06 N47 CSM wt XXXXX. LBS LM wt XXXXX. LBS Accept PRO Reject Key V21E, V22E or V24E Load correct data	2,140	Value of mass used in non-DAP coding not updated unless vehicle configuration bit is 1, 2, or 6. During P40 TVC DAP reduces value for weight linearly, as function of SPS maneuver time. Maneuvers performed without using P40 could cause CMC's knowledge of weight to be compromised.
4	FL V06 N48 P Trim XXX.XX DEG Y Trim XXX.XX DEG Accept PRO - Return to prog in progress Reject Key V21E, V22E or V24E Load correct data		If burn >0.42 second, trim values will be updated by CMC during burn. Do not load engine gimbal trim angles >9°.
5	To activate DAP		To be done first time DAP started or after fresh start.

R1

Vehicle Config.	Quad A/C for $\ddot{X}$	Quad B/D for $\ddot{X}$	Err Deadband	Rate Select
0 = No Dap 1 = CSM 2 = CSM & LM 3 = CSM & SIVB 6 = CSM & LM (Ascent Stg only)	0 = Fail A/C 1 = Use A/C	0 = Fail B/D 1 = Use B/D	0 = ± 0.5° 1 = ± 5.0°	0 = 0.05°/sec 1 = 0.2°/sec 2 = 0.5°/sec 3 = 2.0°/sec

R2

Roll Quad Select	Quad A	Quad B	Quad C	Quad D
0 = Use B/D 1 = Use A/C	0 = Fail 1 = Use	0 = Fail 1 = Use	0 = Fail 1 = Use	0 = Fail 1 = Use

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR CMP		CMC MODE - FREE Key V46E	1 2,140	Prevents inadvertent jet firings. Activates DAP.
		4.8.2.2 RCS DAP Attitude Deadband Change Procedure		This procedure will change RCS DAP att deadband to ±2.5, 10, 15, 20, 25, or 30°. Alternate method of establishing desired deadbands is to use V79 procedures, loading desired deadband, and specify zero rate.
		CMC - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14 RCS DAP - activate (req), 4.8.2.1 SCS - on (desired), 4.8.4.2		
	1	Sel CMC Att Cont - auto, 4.7.1.6		
	2	Sel 5.0° dbd in RCS DAP, 4.8.2.1		
	3	Key V21 N01E 3255E Load D Band (see table)		

Desired dbd	D Band
±2.5°	0343E
±10°	1616E
±15°	2525E
±20°	3434E
±25°	4343E
±30°	5252E

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	4	To return to 5.0° dbd THC - CW, then neut		Center of deadband shifted.
	or	Key V48E PRO PRO PRO	2,140	Center of deadband not affected.
		4.8.2.3 RCS DAP Orbital Rate Procedure		
		CMC - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14 SCS - on (desired), 4.8.4.2 RCS DAP - load & activate (req), 4.8.2.1 (Use R03 to disable 2 adjacent RCS quads) Ysm aligned to V x R (If R x V, complement numbers for ZZZZZ)		To minimize RCS propellant consumption.
	1	Perform (V49) R62, 4.8.3.4 Load gmbl angles for init of orbrate		Gimbal angles loaded are those that are to be at initiation of orbital rate rotation. MGA should be zero.
	2	If desired Key V37E XXE (non-att cont prog)		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	3	Establish orbrate For rates 0.1°/sec or less, load oct numbers corresponding to desired mnvr rate from following table For rate 0.5°/sec, go to 5		
		Key V21 N01E 1013E,E (Set HOLD FLG zero)	2,140	Sets HOLD FLG to zero and inhibits maneuver until after data load.
		Key V24 N01E 3127E VVVVVE WWWWWE		
		Key V24E 3131E XXXXXE YYYYYE		
		Key V21E 3200E ZZZZZE		
		Key V21 N01E 1332E 70000E (Set HOLD FLG negative)		Final ENTR initiates maneuver.
		Mnvr in progress		

STA/T STEP	PROCEDURE	PANEL	REMARKS

4 To term mnvr, go to 8

ORBRATE deg/sec	CDUX 0 deg	+90 deg	+180 deg	+270 deg
-0.100	VVVVV = 77774 WWWWW = 54300 XXXXX = 00000 YYYYY = 61300 ZZZZZ = 42676	00000 61300 00003 23500 42676	00003 23500 00000 16500 42676	00000 16500 77774 54300 42676
-0.095	VVVVV = 77774 WWWWW = 62200 XXXXX = 00000 YYYYY = 62000 ZZZZZ = 44250	00000 62000 00003 15600 44250	00003 15600 00000 16000 44250	00000 16000 77774 62200 44250
-0.090	VVVVV = 77774 WWWWW = 70000 XXXXX = 00000 YYYYY = 62600 ZZZZZ = 45622	00000 62600 00003 10000 45622	00003 10000 00000 15200 45622	00000 15200 77774 70000 45622
-0.085	VVVVV = 77774 WWWWW = 75600 XXXXX = 00000 YYYYY = 63400 ZZZZZ = 47173	00000 63400 00003 02200 47173	00003 02200 00000 14400 47173	00000 14400 77774 75600 47173

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Basic Date 17 July 1970 Change Date Page 4-292

STA/T STEP	PROCEDURE			PANEL	REMARKS
ORBRATE deg/sec	CDUX				
	0 deg	+90 deg	+180 deg	+270 deg	
-0.080	VVVVV = 77775 WWWWW = 43400 XXXXX = 00000 YYYYY = 64100 ZZZZZ = 50545	00000 64100 00002 34400 50545	00002 34400 00000 13700 50545	00000 13700 77775 43400 50545	
-0.075	VVVVV = 77775 WWWWW = 51300 XXXXX = 00000 YYYYY = 64700 ZZZZZ = 52117	00000 64700 00002 26500 52117	00002 26500 00000 13100 52117	00000 13100 77775 51300 52117	
-0.070	VVVVV = 77775 WWWWW = 57100 XXXXX = 00000 YYYYY = 65500 ZZZZZ = 53467	00000 65500 00002 20700 53467	00002 20700 00000 12300 53467	00000 12300 77775 57100 53467	
-0.065	VVVVV = 77775 WWWWW = 64700 XXXXX = 00000 YYYYY = 66300 ZZZZZ = 55041	00000 66300 00002 13100 55041	00002 13100 00000 11500 55041	00000 11500 77775 64700 55041	

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STA/T STEP	PROCEDURE				PANEL	REMARKS
	CDUX					
ORBRATE deg/sec	0 deg	+90 deg	+180 deg	+270 deg		
-0.060	VVVVV = 77775 WWWWW = 72500 XXXXX = 00000 YYYYY = 67100 ZZZZZ = 56413	00000 67100 00002 05300 56413	00002 05300 00000 10700 56413	00000 10700 77775 72500 56413		
-0.055	VVVVV = 77776 WWWWW = 40300 XXXXX = 00000 YYYYY = 67600 ZZZZZ = 57765	00000 67600 00001 37400 57765	00001 37400 00000 10200 57765	00000 10200 77776 40300 57765		
-0.050	VVVVV = 77776 WWWWW = 46200 XXXXX = 00000 YYYYY = 70400 ZZZZZ = 61337	00000 70400 00001 31600 61337	00001 31600 00000 07400 61337	00000 07400 77776 46200 61337		
CMP 5 Ysm aligned to V X R (If R x V, complement numbers for AAAAA and ZZZZZ)					2,140	
6 Key V21 NO1E 1013E,E (set HOLD FLG zero)						Sets HOLD FLG zero and inhibits maneuver until after data load.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CMP	7	Establish orbrate (0.5°/sec) Load oct numbers corresponding to mnvr rate from following table Key V24E 3127E VVVVVE WWWWWE Key V24E 3131E XXXXXE YYYYYE Key V24E AAAAAE ZZZZZE Key V21E 1013E 70000E (set HOLD FLG negative)	2,140	Final ENTR initiates maneuver.

	CDUX			
	0°	180°	7.25°	187.25°
VVVVV	77755	00022	77722	00022
WWWWW	76077	01700	71351	06426
XXXXX	77775	00002	---	---
YYYYY	66367	11410	---	---
AAAAA	77773	77773	77773	77773
ZZZZZ	56272	56272	56272	56272

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR	8	To term mnvr CMC MODE - HOLD	1	
CMP		or Key V49E, return to 1	2,140	
		or Key V46E		
		or RHC - out of detent		
		or Key V37E		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.3 EXTENDED VERBS		
		4.8.3.1 (V35) DSKY Condition Light Test		Procedure designed to test CMC/caution and warning, DSKY interface.
		CMC - on (req), 4.8.1.3		
CMP	1	Key V37E 00E (req)	2,140	Must be performed while in P00.
	2	Key V35E		
	3	Mon the following events		
		a. All DSKY condition lts - on		
		b. ISS warning lt - on CMC warning lt - on		
		c. All DSKY numerical windows disp 8 Sign positions in R1, R2, R3 show + V, N windows flash		
		Wait 5 sec		
		d. All DSKY warning lts - out		NO ATT will be left on if coarse align occurring.
		e. ISS lt - out CMC lt - out		
		f. Old PROG number will be disp Interrupted disp (if any) will be restarted		

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.3.2 (V42) Torque Gyros		Fine aligns stable member by torquing gyros (primarily for ground use).
		CMC - on (req), 4.8.1.3 ISS - on (req), 4.8.1.3 & 4.14		
CMP	1	Key V37E 00E	2,140	
	2	For Load <100° Key V42E		
		Poss OPR ERR		If another extended verb active, or IMU stall routine in use.
	or	For Load >99.999° Key V21 N02E 2757E XXXXXE N15E XXXXXEE YYYYYEE YYYYYEE ZZZZZEE ZZZZZE Key V42E		Load >90 deg should not be performed during flight.
		Poss OPR ERR		If another extended verb active, or IMU stall routine in use.
	3	FL V21 N93 (request load)		If SC CONT at CMC and CMC MODE at AUTO or HOLD, DAP will maneuver vehicle to follow the platform as it moves.

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Δ Gyro X, Y, Z XX.XXX DEG	2,140	Registers initially blank.
	Accept Load desired data DSKY displays V42 NO ATT lt - out		
	Reject V33E DSKY displays V42 NO ATT lt - out		Key V33E if gyro torquing registers loaded prior to keying V42E. Also refer to 4.6.1.3, note 3m.
	4.8.3.3 (V43) Load FDAI Error Needles		Loads crew specified angles into FDAI error needles (primarily for ground use).
	CMC - on (req), 4.8.1.3 ISS - on (req), 4.8.1.3		
	1 Key V37E 00E		V43E can be executed only from P00.
	2 Key V43E		
	Poss OPR ERR		V43E cannot be executed if CMC not in P00, IMU in coarse align or zero ICDU mode, or if another extended verb active. (Latter is constraint after liftoff.)
	3 FL V21 N22 (request load) R, P, Y XXX.XX DEG		Registers initially blank.
	Load desired err angles		Maximum effective angle which may be loaded is ±16.88 degrees.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.3.4 (V49) CSM Crew Defined Maneuver (R62)		Provides method of performing CMC controlled maneuver to crew defined attitude.
		CMC - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14 SCS - on (req), 4.8.4.2		
CMP	1	Key V37E 00E	2,140	Routine R62 may be called from P00 only.
	2	Sel Tot Att (ISS) Disp, 4.7.2.5		Both FDAIs recommended so either reference system (IMU or GDC) may be monitored. (CMC attitude error and rate displays available.)
	3	Key V49E		
		Poss OPR ERR		If another extended verb active.
	4	FL V06 N22 (fnl gmbl angles) R, P, Y XXX.XX DEG		
		Accept PRO Reject V25E load desired gmbl angles		
		(R60 - Attitude Maneuver Routine)		Provides for maneuver (automatically or manually) to specified attitude.
	5	FL V50 N18 (auto mnvr request) R, P, Y XXX.XX DEG		Required gimbal angles.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
CDR	Accept	BMAG MODE (3) - RATE 2	1	
		Sel CMC Att Cont Auto, 4.7.1.6		
CMP		PRO	2,140	May be performed second time as attitude trim.
		V06 N18		Static display until completion of auto manuever and reverts to FL V50 N18.
		R, P, Y XXX.XX DEG		
		Mon auto mnvr on FDAI		
	Reject	Key V62E		Selects Mode 2, total attitude error on FDAI needles.
		RHC - Null FDAI needles		Any input from RHC (RHC out of detent) will be interpreted by CMC as a manual override and will cause immediate termination of auto maneuver calculation.
		When att satisfactory		
		ENTR		
	4.8.3.5	(V67) Start W-Matrix RSS Error Display		Provides display of RSS position and velocity errors, and opportunity to load new initialization values. However, initialization will not take place until next opportunity.
		CMC - on (req), 4.8.1.3		
	1	Key V67E		
		Poss OPR ERR		If another extended verb in process.
		Exit		
	2	FL V06 N99		
		POS ERR XXXXX. FT		RSS value of position error.
		VEL ERR XXXX.X FPS		RSS value of velocity error.

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Option code 0000X	2,140	Option code: (initially 00000) 00001 - Rendezvous 00002 - Orbital 00003 - Cislunar **R3 must be loaded for desired option. Otherwise, reinitialization will not occur.** Bypasses reinitialization, if R3 = 00000. To initialize at new values. Initialization occurs next time a measurement is made. N99 values to be loaded to obtain desired POS ERR and VEL ERR elements with corresponding octal values for erasable.

Accept PRO
Reject Key V25E
Load desired data (per following tables)

W-MATRIX TABLE (V67)

WRENDPOS		2000-P20	WRENDVEL		2001-P20
WORBPOS		2004-P22	WORBVEL		2005-P22
WMID POS		3000-P23	WMIDVEL		3001-P23
N99 R1	1000 ft	OCT	N99 R2	fps	OCT
10000	10	137	10	10	762
08000	8	114	8	8	620
06000	6	71	6	6	453
04000	4	46	4	4	307
02000	2	23	2	2	144
01000	1	11	1	1	61
00800	.8	7	.8	.8	50
00600	.6	5	.6	.6	34
00400	.4	3	.4	.4	24
00300	.2	2	.2	.2	10
00100	.1	1	.1	.1	5

STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.8.3.6 (V74) Initialize Erasable Dump Via Downlink		Dumps all eight banks of erasable memory via downlink.
	CMC - on (req), 4.8.1.3		
CMP	1 Key V74E (V74 will deliver two complete dumps)	2,140	
	4.8.3.7 (V91) Display Banksum		Displays sum of each bank for comparison.
	CMC - on (req), 4.8.1.3		
	1 Key V37E 00E		Procedure must be performed in P00.
	2 Key V91E		
	Poss OPR ERR		If another extended verb active.
	3 FL V05 N01		
	Banksum XXXXX		Sum of bits of chosen bank.
	Bank No. XXXXX		Number of bank being read.
	Bugger word XXXXX		Factor required to make |R1| = |R2|.
	Accept V34E (halt summing)		Expected bank and banksum acceptable (|R1| = |R2|).
	Reject PRO, recycle 3 (next bank)		43 banks.

STA/T	STEP	PROCEDURE	PANEL	REMARKS
		4.8.4 SCS GENERAL		
		4.8.4.1 SCS Power Down		Describes safe power-down configuration.
	1	Provide Safe Sys Configuration		
CDR		EMS FUNC - OFF	1	
		EMS MODE - STBY		
		AUTO RCS (16) - OFF	8	
		BMAG MODE (3) - RATE 2	1	
		SPS THRUST - NORM		Normal position selected to prevent inadvertent SPS firing.
	2	Remove SCS Pwr		
		TVC SERVO PWR (both) - OFF	7	
		FDAI/GPI PWR - OFF		
		LOGIC 2/3 PWR - OFF		
		ELEC PWR - OFF		
		SIG CONDR/DR BIAS PWR (both) - OFF		
		BMAG PWR (both) - WARMUP		
		RHC PWR NORM (both) - OFF	1	
		xxxxxxxxxxxxxxxxxxxxx		
		For tot pwr down		When BMAG switches set to OFF, 40-minute warmup may be required (BMAG 1 and 2 TEMP lights extinguish when operating temperature is reached) before normal operation of BMAGs. If set from ON to WARMUP, BMAG TEMP lights should remain out.
		W BMAG 1 PWR - OFF	7	
		xxxxxxxxxxxxxxxxxxxxx		
	3	Pwr Down ORDEAL		
		FDAI sw (both) - INRTL	13	
		EARTH/LUNAR - PWR OFF		
		LTG - OFF		